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## TNT EQUIVALENCY OF BULK NITROCELLULOSE

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US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND  
LARGE CALIBER  
WEAPON SYSTEMS LABORATORY  
DOVER, NEW JERSEY

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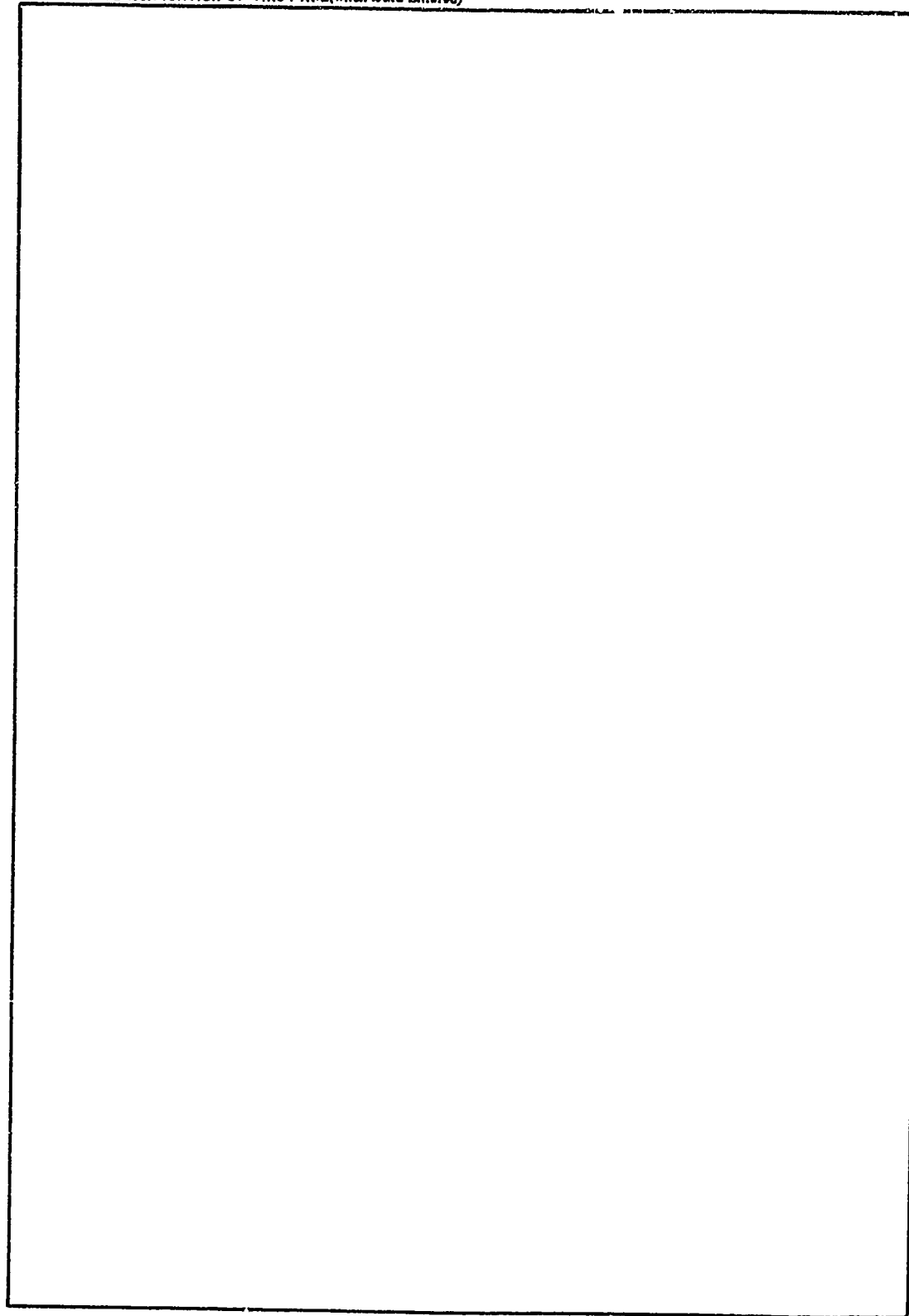
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This project was accomplished as part of the U.S. Army's Manufacturing Methods and Technology Program. The primary objective of this program is to develop, on a timely basis, manufacturing processes, techniques, and equipment for use in production of Army materiel.		
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MMT-ammunition                      Scaled shipping container Nitrocellulose                      Peak side-on pressure TNT equivalency                      Scaled positive impulse Apparent bulk density                      Scaled distance Scaled weigh feeder tub                      Thermal dehydration unit		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
Peak side-on blast overpressure and scaled positive impulse have been measured for Nitrocellulose MIL-N-244A using configurations that simulate in-plant processing. Quantities of 11.34, 19.5, 22.68, 45 and 63.5 kg were tested in cylindrical storage containers, an orthorhombic scaled weigh feeder tube and a simulated section of the Thermal Dehydration Unit. High explosive equivalency values for each test series were obtained as a function of scaled distance by comparison to known pressure and impulse characteristics for TNT hemispherical surface bursts.		

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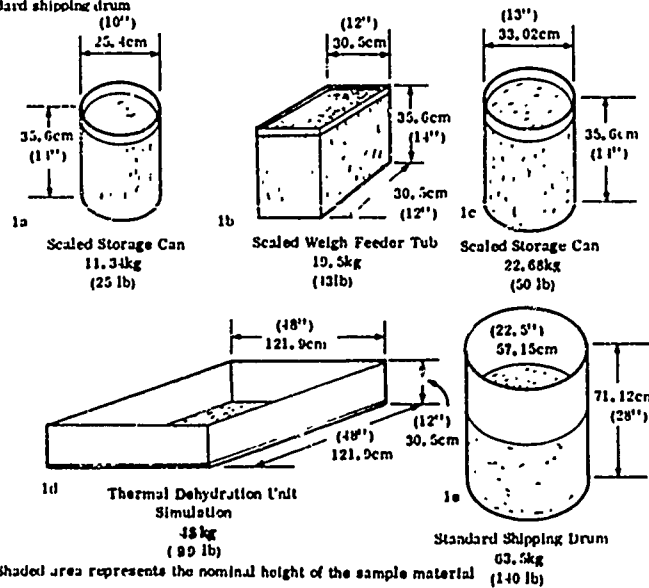
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## SUMMARY

Nitrocellulose, 13.15% nitrogen MIL-N-244A Grade C (Lot number RAD78F0015027) was detonated in configurations representative of in-plant scaled storage cans, scaled weigh feeder tub and a simulated section of the Thermal Dehydration Unit. Blast output parameters were measured and TNT equivalency was computed based on comparison with TNT hemispherical surface bursts. The results of these tests are presented in the table below and in figures on the following page. To within experimental error the pressure and impulse of the nitrocellulose with an L/D ratio greater than one-to-one in charge weights of 11.34, 19.5, 22.7 and 63.5 kg scaled with the cube root of the charge weight. TNT equivalency was greater than 100% at the near field values ( $Z \leq 6\text{m/kg}^{1/3}$ ) and less than 100% for the far field values ( $Z > 6\text{m/kg}^{1/3}$ ). TNT equivalency values for the Thermal Dehydration Unit, 45 kg and with an L/D ratio less than one-to-one, were generally less than 100% at all scaled distances with the exception of ( $Z = 1.19\text{m/kg}^{1/3}$ ) which was greater than 100%, and the far field value of  $7.14\text{ m/kg}^{1/3}$  where the impulse equivalency was 105%.

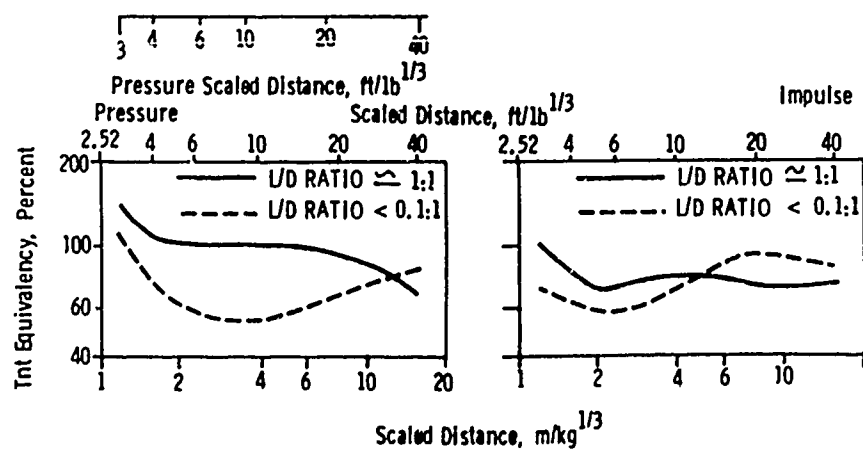
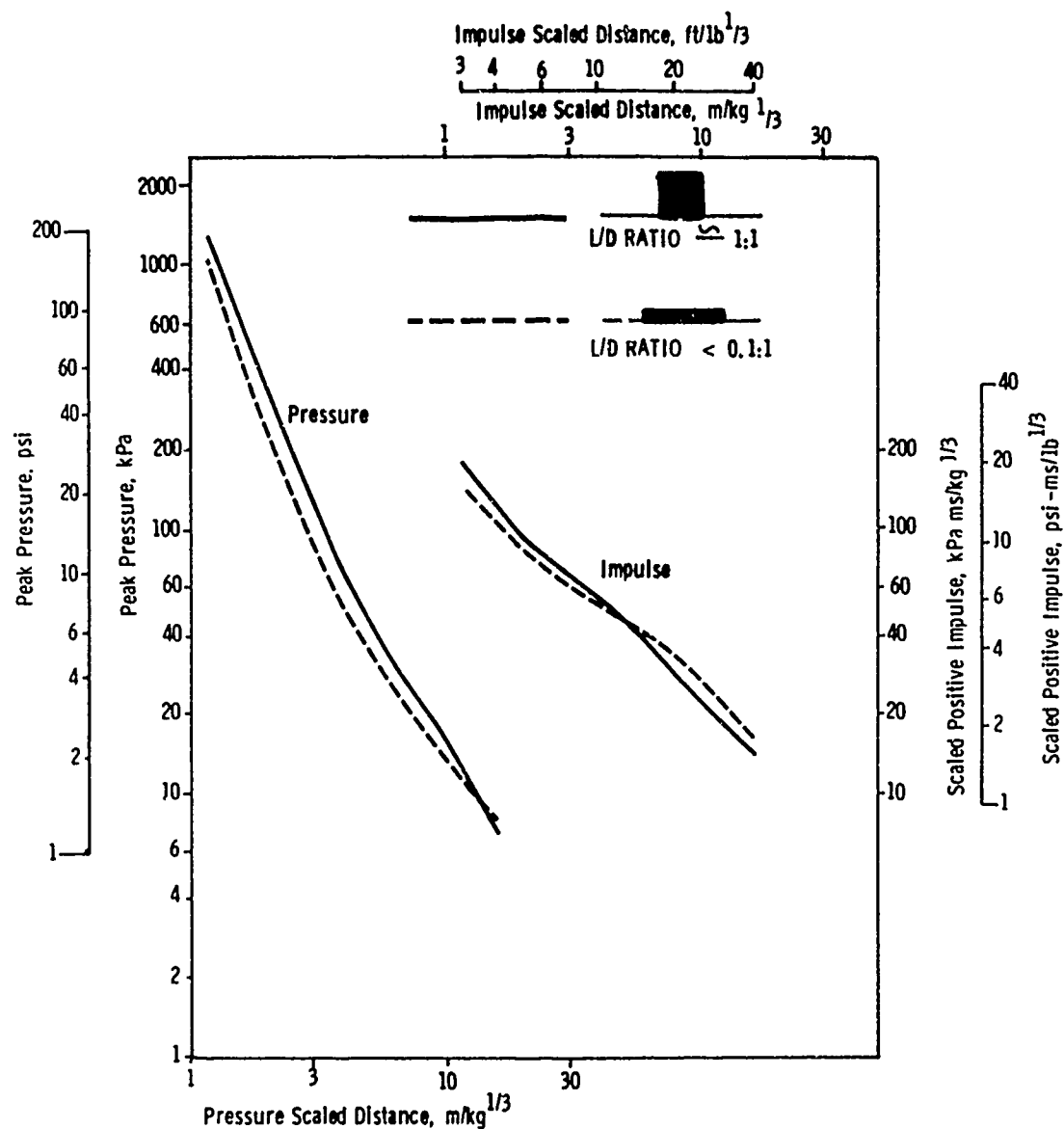
Configuration Mass	Pressure (P) and impulse (I) TNT equivalency (E) at scaled distance											
	1.19m/kg <sup>1/3</sup> (3.0 ft/lb <sup>1/3</sup> )		1.61m/kg <sup>1/3</sup> (4.05 ft/lb <sup>1/3</sup> )		2.13m/kg <sup>1/3</sup> (5.38 ft/lb <sup>1/3</sup> )		3.57m/kg <sup>1/3</sup> (9.0 ft/lb <sup>1/3</sup> )		7.14m/kg <sup>1/3</sup> (18.0 ft/lb <sup>1/3</sup> )		15.9m/kg <sup>1/3</sup> (40 ft/lb <sup>1/3</sup> )	
	P	I	P	I	P	I	P	I	P	I	P	I
11.34kg • 19.5kg •• 22.68kg • 63.5kg •••	145	100	105	75	100	65	100	75	95	70	65	70
Thermal dehydration unit 45 kg	130	80	80	70	70	60	60	70	75	105	90	90

- Scaled storage cans
- Scaled weigh feeder tub
- Standard shipping drum



NOTE: Shaded area represents the nominal height of the sample material

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## INTRODUCTION

### BACKGROUND

A Thermal Dehydration Facility (Project 5752666) for continuous manufacturing of nitrocellulose (NC) has been installed at a GOCO Plant. Thermal Dehydration equipment is being installed at another GOCO Plant (Project 5802875) for the CAMBL 1 Line.

At the can pack operation (Project 5752666) the nitrocellulose (5%) is pumped to the Thermal Dehydration Unit where it enters as a 95% water slurry. After the conveyor of the unit has moved the material for 1.83 m (6 ft), 3.93 m (12.9 ft), and approximately 7.62 m (25 ft), its moisture content has been reduced to 30%, 8% and 0.5 to 1% respectively. At this point of the drying process the nitrocellulose material is in cake form 19 mm (0.75 in) thick by 2.44 m (8 ft) wide with a density of 1.6 g/cm<sup>3</sup>. The nitrocellulose is sprayed with ethyl alcohol (to a maximum of 14%), the cake is broken up, and conveyed to a weigh feeder where it is weighed into storage containers with a height-to-diameter ratio 68.6/55.9 cm (27/22 in).

The NC drying process is the same for Project 5802875 except, as the material leaves the Thermal Dehydration Unit, it is conveyed to a gravimetric feeder, and fed into a pre-mixer and mixed with other materials.

Safety engineering and cost effectiveness considerations require knowledge of hazardous material characteristics as an input to facility design requirements. In this instance, specific data is required on the explosive output characteristics of nitrocellulose in quantities and configurations representative of those found in processing.

### OBJECTIVE

To determine the maximum output from the detonation of nitrocellulose in terms of the airblast overpressure and positive impulse. The measured pressure and impulse data will be compared with known TNT test data (curves) to determine the equivalency of nitrocellulose in relation to TNT.

## EXPERIMENTAL METHODS

### MATERIALS

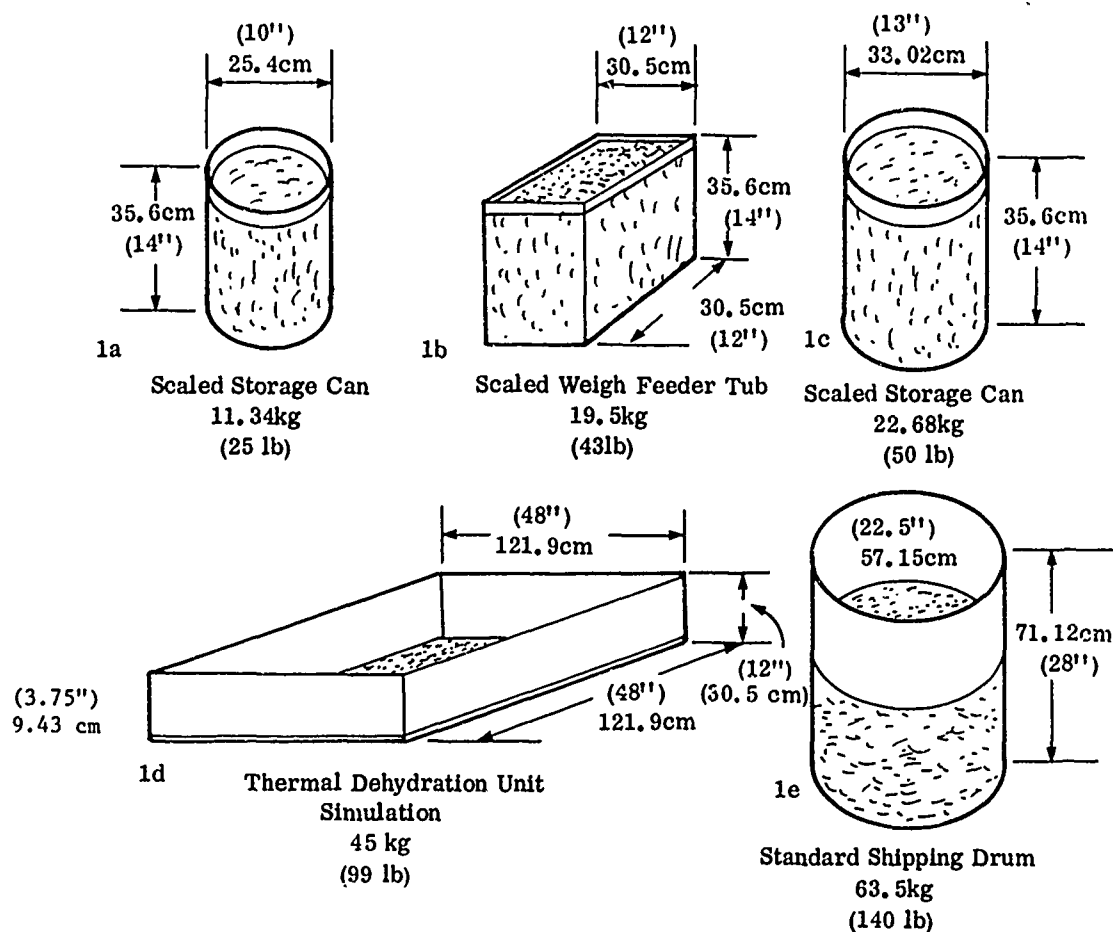
The test material was dehydrated nitrocellulose 13.15% nitrogen Mil-N-244A Grade C (Lot number RAD78F0015027). It was received in 208-liter (55-gallon) steel drums approximately 25% alcohol wet, with a net mass of 107.9 kg (238 lb).

### TEST PLAN

Airblast output was evaluated for masses and configuration of nitrocellulose representative of four in-plant situations. Physical characteristics of the test items were as follows:

- (1) A cylindrical container (figure 1a) was used to simulate a scaled storage container. The container was constructed from 16-gage steel with a height of 35.6 cm by 25.4 cm diameter (14 in by 10 in) and was filled with 11.34 kg (25 lb) of nitrocellulose 14% alcohol wet.
- (2) An orthorhombic container (figure 1b) was used to simulate a scaled weigh feeder tub. This container was constructed from 16-gage steel with dimensions of 35.6 cm by 30.5 cm by 30.5 cm (14 in by 12 in by 12 in). This container was filled with 19.5 kg (43 lb) of nitrocellulose 14% alcohol wet.
- (3) A cylindrical container (figure 1c) was used to simulate a scaled storage container. The container was constructed from 16-gage steel with dimensions of 35.6 cm by 33 cm (14 in by 13 in). This container was filled with 22.68 kg (50 lb) of nitrocellulose 14% alcohol wet.
- (4) An orthorhombic fixture (figure 1d) was used to simulate a section of the Thermal Dehydration Unit (TDU). The fixture was constructed from plywood with dimensions of 121.9 by 121.9 by 30.5 cm (48 in by 48 in by 12 in). The bottom of the fixture was open and covered with wire mesh window screen. Nitrocellulose, 53 kg (116 lb) at 14% alcohol wet was weighed out and spread evenly to a height of approximately 2.54 cm (1 in). A lid was placed atop the fixture and a dry air purge with a dew point of  $-76.1^{\circ}\text{C}$  ( $-105^{\circ}\text{F}$ ) was allowed to run for a minimum of 30 minutes to remove the alcohol from the material. The weight of the material at time of test was 45 kg (99 lb).
- (5) A full-scale shipping drum (figure 1e) was used to test 63.5-kg (140-lb) quantities to determine cube root scaling as a function of charge weight. These tests were in addition to those called for in the original test plan. Nitrocellulose 14% alcohol wet was used in this test series.

A Composition C1 conically shaped booster charge with a ratio of 1.5:2 height to diameter (h/d) was centered on top of each test charge. The height to diameter ratio for the Thermal Dehydration Unit configuration was 1:4. The booster was initiated with an engineer's special J2 blasting cap inserted at the apex and embedded to the center of the cone.



NOTE: Shaded area represents the nominal height of the sample material

Figure 1-Test Container Configurations

The test plan called for booster weights varying between 6 and 8% with a maximum of 10%. An initial test was conducted with 5.44 kg (12 lb) nitrocellulose material 14% alcohol wet and a 0.5 kg (1.2 lb) booster (C4) in a container 20.3 cm (3 in.) diameter and 30.5 cm (12 in.) high. No mass detonation occurred. ARRADCOM approved the use of the containers shown in figure 1 and the employment of a 10% booster for all tests in all configurations.

The test charges in each configuration were placed on a 1010 carbon steel witness plate 1.27 cm (0.5 in) thick with the dimensions being at least 5.08 cm (2 in) greater than the size of the test container.

#### INSTRUMENTATION

Twelve PCB Piezotronics side-on-pressure transducers were mounted flush to the surface in each of two sand-filled arrays within the test area shown in figure 2. Distances from the charge to the transducer corresponded to scaled distances from 1.19 to 15.87  $\text{m/kg}^{1/3}$  (3 to 40  $\text{ft/lb}^{1/3}$ ). The transducers were individually calibrated prior to the beginning of each test series with pressure pulses from a standard solenoid-actuated air pressure calibration fixture, adjusted to correspond to expected blast pressure based on an assumed TNT equivalency of 100 percent. Signal line continuity and channelization were checked prior to each test along with a daily electrical calibration of the recording system. Details of distances between charge and transducers, calibration pressure and expected peak blast pressure at each distance are shown in table 1.

Each transducer with inherent charge amplifier was connected to an underground coaxial cable system which leads to the Test Control Center. All signals are amplified and conditioned by PCB Model 494A06 Power Supply Amplifier. The signals were recorded in digital form on 4 Blomation Model 8100 Transient Recorders and in analog form on a Honeywell Model 96 Tape Recorder.

Photographic coverage was restricted to one test of each configuration (figure 3). Motion picture coverage included a Mitchell camera Model H516-E4 operating at 500 frames per second (fps) and one Mitchell camera (same model) operating at 24 fps. Before and after color still photographs were taken of each test showing typical setup and results. Standard meteorological data were recorded for each test.

TABLE 1. TRANSDUCER CALIBRATION AND PLACEMENT FOR  
NITROCELLULOSE EQUIVALENCY TESTING

Channel number	Scaled distance m/kg <sup>1/3</sup> (ft/lb <sup>1/3</sup> )	Full-scale calibration pressure kPa (psig)	Expected pressure kPa (psig)	R distance in meters (ft) from charge			
				R <sub>1</sub> distance in meters (ft) from charge			
				Charge weight 11.34 kg (25 lb)	Charge weight 22.68 kg (50 lb)	Charge weight 41.87 kg (92.3 lb)	Charge weight 45 kg (99 lb)
1, 2	1.19 (3.0)	1034 (150)	917 (133)	2.67 (8.77)	3.37 (11.05)	4.13 (13.558)	4.46 (14.63)
3, 4	1.61 (4.05)	517.1 (75)	479.74 (69.58)	3.56 (11.696)	4.49 (14.738)	5.51 (18.077)	5.95 (19.508)
5, 6	2.13 (5.38)	344.7 (50)	242.49 (35.17)	4.81 (15.789)	6.06 (19.89)	7.44 (24.404)	8.03 (26.336)
7, 8	3.57 (9.0)	103.4 (15)	87.9 (12.74)	8.02 (26.32)	10.11 (33.2)	12.40 (40.67)	13.38 (43.89)
9, 10	7.14 (18.0)	34.5 (5)	24.9 (3.6)	16.04 (52.63)	20.21 (66.3)	24.79 (81.347)	26.76 (87.786)
11, 12	15.87 (40.0)	34.5 (5)	7.58 (1.1)	35.64 (117.0)	44.92 (147.4)	55.10 (180.77)	59.46 (195.08)

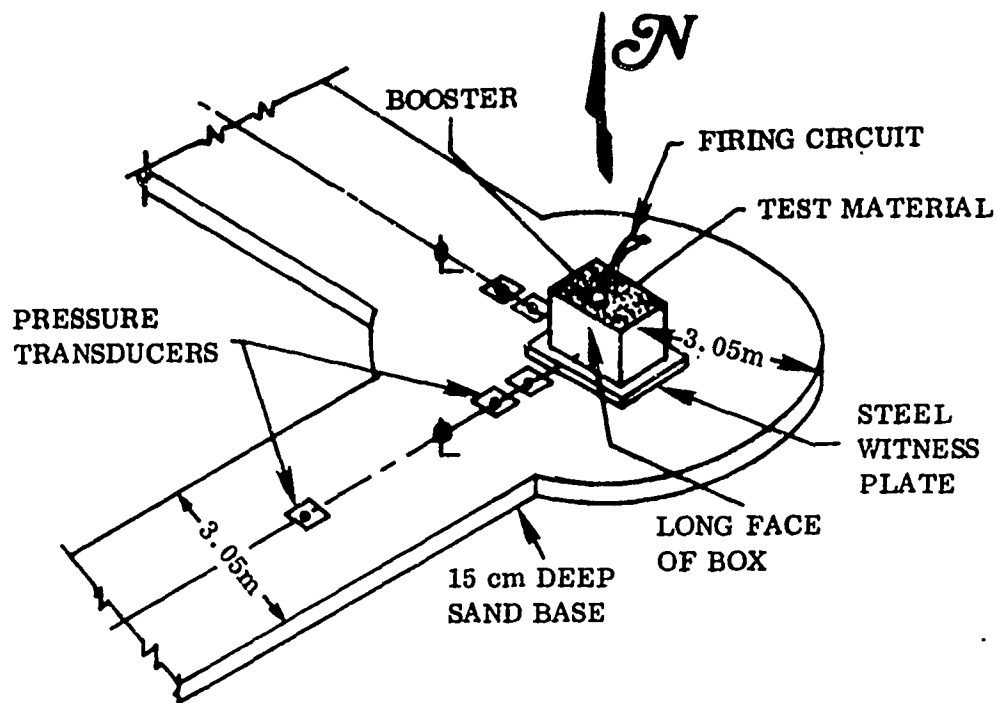


Figure 2. Typical Charge Placement for Equivalency Tests

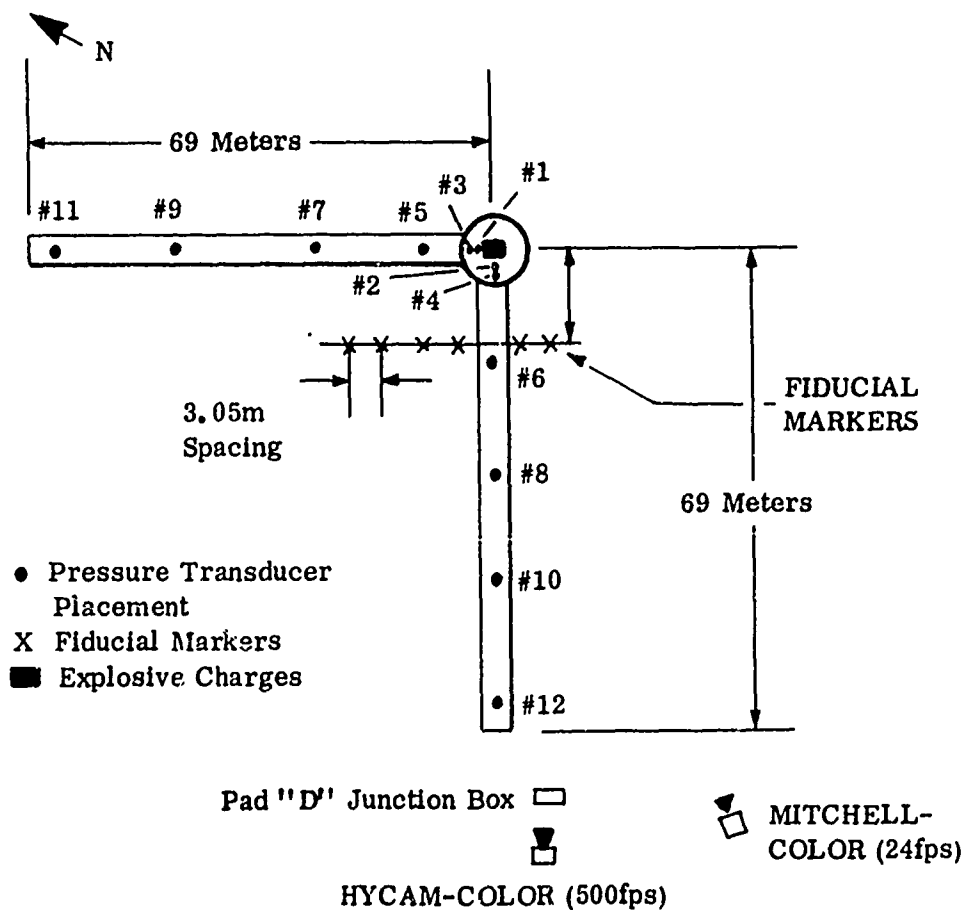


Figure 3. Test Area Showing Transducer and Camera Placement

## RESULTS

### DATA ANALYSIS

Peak blast overpressure and positive impulse information were obtained in digital form by the Tektronix 4051 Graphic System. After exclusion of inconsistent results that could be attributed to instrumentation or explosive malfunction, average values for pressure and impulse were used to calculate equivalencies based on comparison to data from TNT hemispheres<sup>1</sup> (figure 4). McKown<sup>2</sup> describes the program written for the Graphic System which utilizes an iterative process first reported by Swatosh and Cook<sup>3</sup> which factors out the contribution of the booster charge weight and calculates the pressure and impulse equivalencies (see Appendix C). With the effect of the booster weight factored out, the calculated TNT equivalencies were tabularized and plotted as functions of sample scaled distance.

### TEST RESULTS

Data sheets for all tests with pertinent measured parameters are given in Appendix A. Selected pretest and posttest still photographs are given in Appendix B. Test numbers shown are for local reference only and provide access to original range data files.

Average pressure, scaled positive impulse, and time of arrival data are summarized by test configuration in tables 2 through 6 and figures 5 through 9. Composite pressure and impulse curves for all charge weights and configurations are given in figure 10, and are summarized in tables 2 through 7 of this report. Percent TNT equivalencies for all charge weights and configurations are shown in figure 11 as functions of scaled distance. Deviation from cube-root scaling for pressure at each scaled distance versus charge weight for nitrocellulose with an L/D ratio is shown in figure 12. Fireball duration and diameter as measured from the high speed motion pictures are given in table 8.

### DISCUSSION

The plots of peak pressure and scaled impulse versus scaled distance (figures 5, 6, and 7) for the L/D ratio of 1:1 or greater show the same general trend. Compared to (figure 4) corresponding TNT hemispherical surface burst, the observed pressures are greater than 100 percent at the near field values ( $Z \leq 6 \text{ m/kg}^{1/3}$ ) and less than 100% for the far field values ( $Z > 6 \text{ m/kg}^{1/3}$ ). Impulse versus scaled distance was generally less than 100 percent at all measured distances. The peak pressures for the Thermal Dehydration Unit simulation tests were less than those found in the tests with a nominal L/D ratio 1:1. Peak pressure equivalency was found to be greater than 100% at one near field value of  $1.19 \text{ m/kg}^{1/3}$  and all other pressure equivalencies were less than 100%. Impulse equivalency was found to be less than 100 percent at all scaled distances. The lower pressures and impulse values for the TDU can be attributed to the difference in geometry. Wisotski and Syner<sup>4</sup> and McKown and McIntyre<sup>5</sup> have noted the effect of geometry in producing lower peak pressure and impulse values when the L/D ratio is less than 1:1.

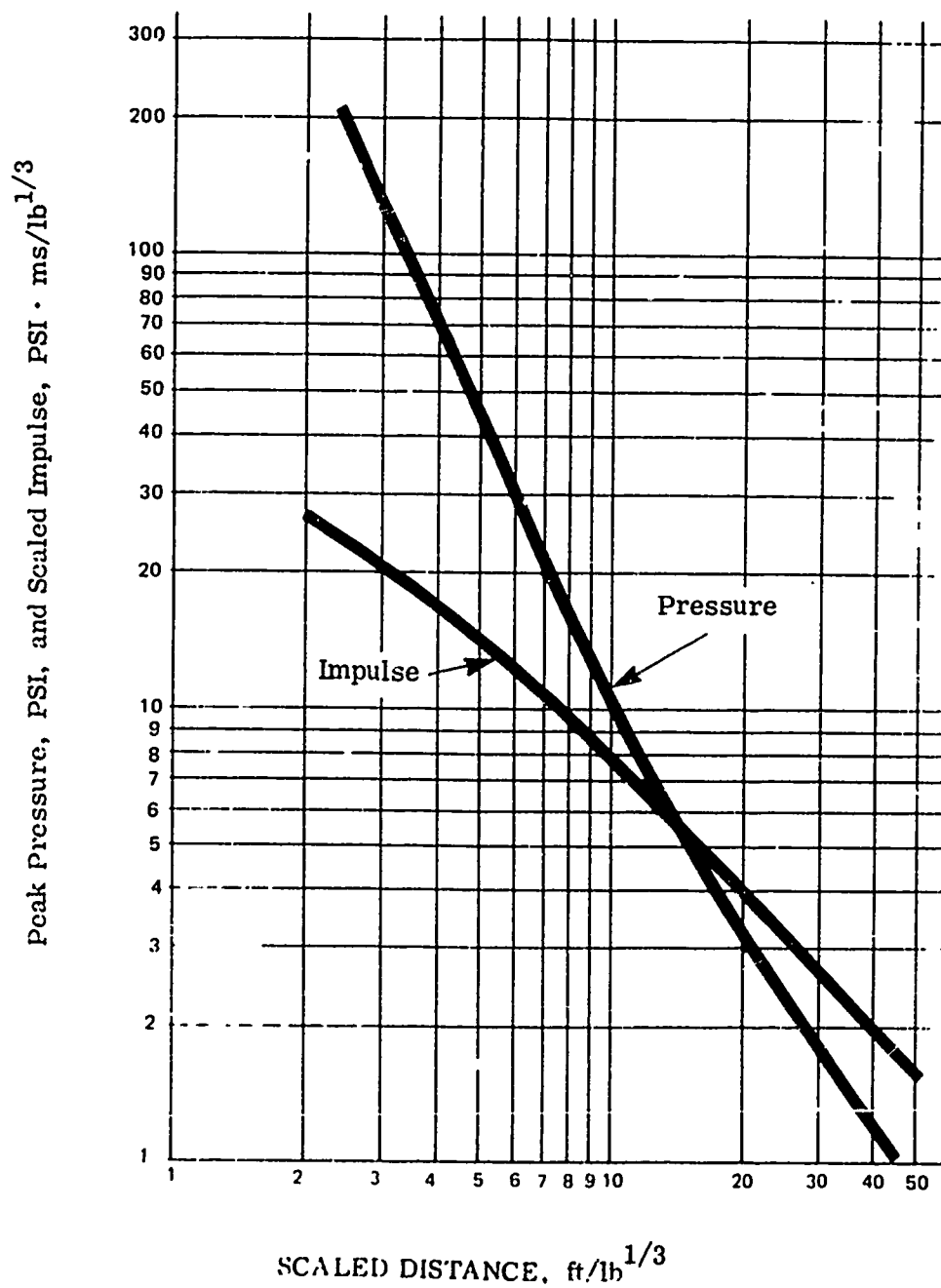


Figure 4. TNT Hemispherical Surface Burst Reference Data



TABLE 2. SUMMARY OF TEST RESULTS, 11.34 kg CHARGE, SCALED STORAGE CONTAINER

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency	Impulse TNT Equivalency
2.67 ( 8.77 )	1.19 ( 3.0 )	2.95	1245.1 (180.6)	170.7 (19.02)	141	93
3.61 ( 11.7 )	1.61 ( 4.05 )	3.89	549.6 (79.71)	118.01 (13.15)	158	74
4.8 ( 15.79 )	2.13 ( 5.38 )	5.51	291.8 (43.3)	79.06 (8.91)	108	57
8.02 ( 26.32 )	3.57 ( 9.0 )	12.24	83.8 (12.15)	59.41 (6.62)	97	72
16.04 ( 52.63 )	7.14 (18.0 )	32.65	23.7 (3.44)	27.64 (3.08)	89	57
35.7 (117.0)	15.87 (40.0 )	86.01	7 (1.02)	13.55 (1.51)	59	63

TABLE 3. SUMMARY OF TEST RESULTS, 19.5 kg CHARGE SCALED WEIGH FEEDER TUB

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency	Impulse TNT Equivalency
3.2 ( 10.51 )	1.19 ( 3.0 )	3	1202.7 (174.43)	166.47 (18.55)	135	81
4.33 ( 14.19 )	1.61 ( 4.05 )	3.98	532.6 (77.24)	121.60 (13.55)	108	76
5.74 ( 18.84 )	2.13 ( 5.38 )	5.84	276.6 (40.12)	22.78 (8.11)	103	48
9.61 ( 31.53 )	3.57 ( 9.0 )	13.83	80.7 (11.71)	67.57 (7.53)	91	66
19.22 ( 63.06 )	7.14 (18.0 )	37.91	25.9 (3.76)	34.01 (3.79)	112	76
42.71 (140.14)	15.87 (40.0 )	102.11	7.58 (1.10)	15.44 (1.72)	72	83

TABLE 4. SUMMARY OF TEST RESULTS, 22.68 kg CHARGE, SCALED STORAGE CONTAINER

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency %	Impulse TNT Equivalency %
3.37 (11.05)	1.19 ( 3.0 )	3.26	1327.8 (192.58)	202.9 (22.61)	156	126
4.49 (14.74)	1.61 ( 4.05)	4.27	543.7 (78.85)	124.47 (13.87)	107	80
6.06 (19.89)	2.13 ( 5.38)	6.51	271.45 (39.36)	90.1 (10.04)	102	71
10.11 (33.2 )	3.57 ( 9.0 )	15.17	88.53 (12.84)	60.13 (6.70)	109	74
20.21 (66.3 )	7.14 (18.0 )	40.24	23.92 (3.47)	31.5 (3.51)	91	71
44.92 (147.4 )	15.87 (40.0 )	107.53	7.31 (1.06)	14.27 (1.59)	65	69

TABLE 5. SUMMARY OF TEST RESULTS, 45 kg CHARGE THERMAL DEHYDRATION UNIT

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi · ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency %	Impulse TNT Equivalency %
1.46 (11.63)	1.25 (3.16)	4.42	1070.8 (155.3)	161.12 (16.84)	132	80
6.02 (19.75)	1.69 (4.26)	6.27	353. (51.18)	108.22 (12.08)	79	69
8 (26.24)	2.25 (5.67)	9.84	194.6 (28.22)	80.41 (8.96)	69	61
13.38 (43.89)	3.76 (9.48)	22.04	59.7 (8.66)	57.52 (6.41)	57	73
26.76 (87.79)	7.52 (18.98)	56.71	19.99 (2.9)	38.50 (4.29)	75	106
59.46 (195.08)	16.71 (42.12)	146.32	7.93 (1.15)	16.51 (1.84)	94	93

TABLE 6. SUMMARY OF TEST RESULTS, 63.5 kg CHARGE, SHIPPING CONTAINER

Radius meters (ft)	Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi $\cdot$ ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency	Impulse TNT Equivalency
4.75 (15.58)	1.19 ( 3.0 )	4.5	1251.4 (181.5)	181.81 (20.76)	143	89
6.33 (20.77)	1.61 ( 4.05)	6.22	469.4 (68.08)	126.4 (14.09)	85	84
8.55 (28.04)	2.13 ( 5.38)	9.57	252.14 (36.57)	93.24 (10.39)	91	76
14.24 (46.73)	3.57 ( 9.0 )	21.28	86.5 (12.54)	58.3 (6.5)	103	69
28.49 ( 93.46)	7.14 (18.0 )	57.1	25.44 (3.69)	34.19 (3.81)	107	81
63.32 (207.73)	15.87 (40.0 )	152.9	7.86 (1.14)	14.27 (1.59)	79	68

TABLE 7. SUMMARY OF TEST RESULTS, COMPOSITE CHARGE WEIGHTS WITH A NOMINAL L/D RATIO OF 1:1

Scaled Distance $m/kg^{1/3}$ (ft/lb <sup>1/3</sup> )	Scaled Time of Arrival (msec)	Peak Pressure kPa (psi)	Scaled Positive Impulse $kPa \cdot ms/kg^{1/3}$ (psi $\cdot$ ms/lb <sup>1/3</sup> )	Pressure TNT Equivalency	Impulse TNT Equivalency
1.19 ( 3.0 )	(0.90)	1433 (207.78)	178.3 (19.87)	143	100
1.61 ( 4.05)	(1.20)	621.08 90.	120.97 (13.48)	106	76
2.13 ( 5.38)	(1.80)	311.21 (45.12)	85.34 (9.51)	101	65
3.57 ( 9.0 )	(4.09)	93.37 (13.56)	60.13 (6.7)	100	74
7.14 (18.0 )	(11)	23.18 (3.36)	31.68 (3.53)	94	71
15.87 (40.0 )	(29.34)	3.29 (.47)	14.36 (1.6)	63	70

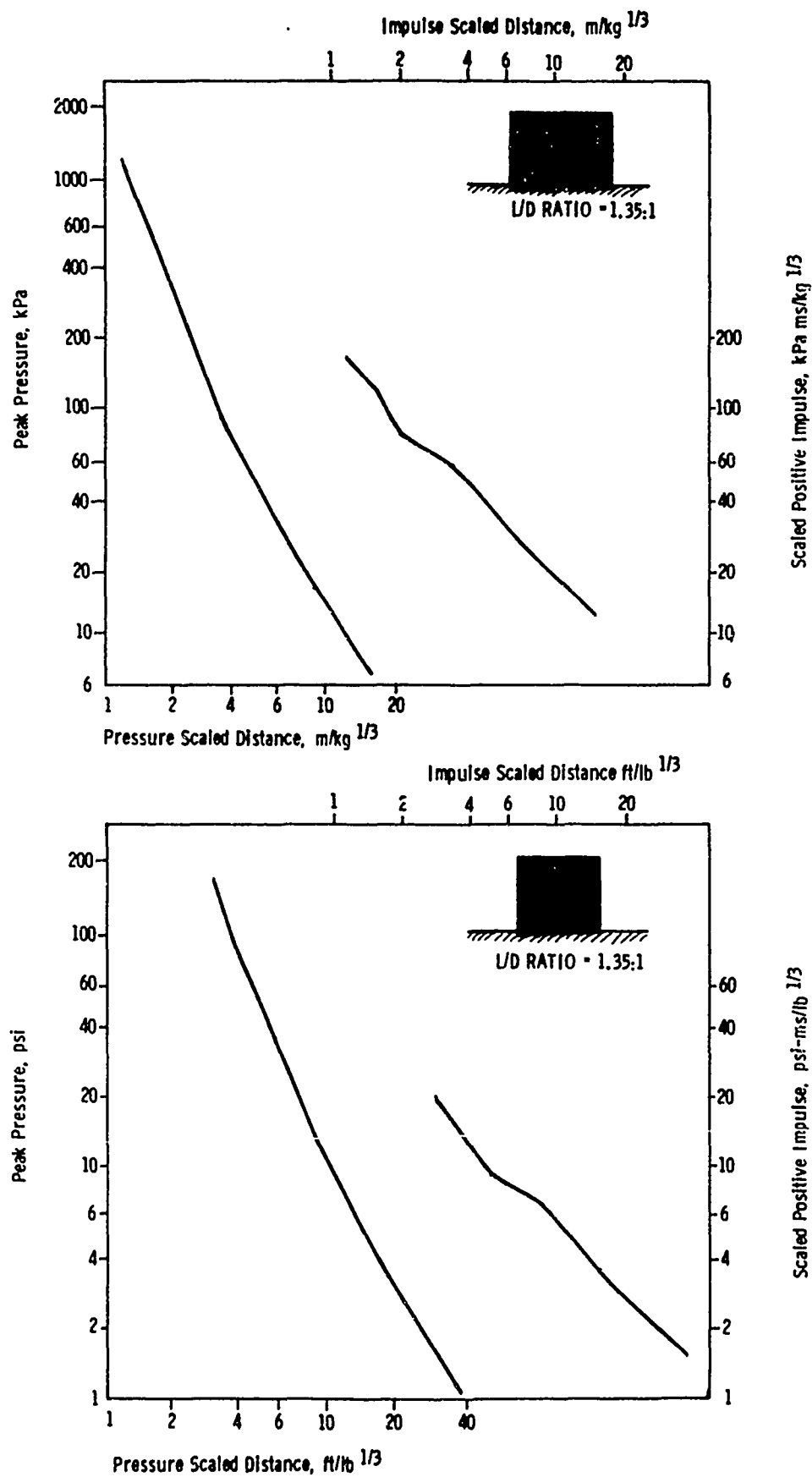


Figure 5. Pressure and Impulse vs. Scaled Distance 11.34 kg Charges

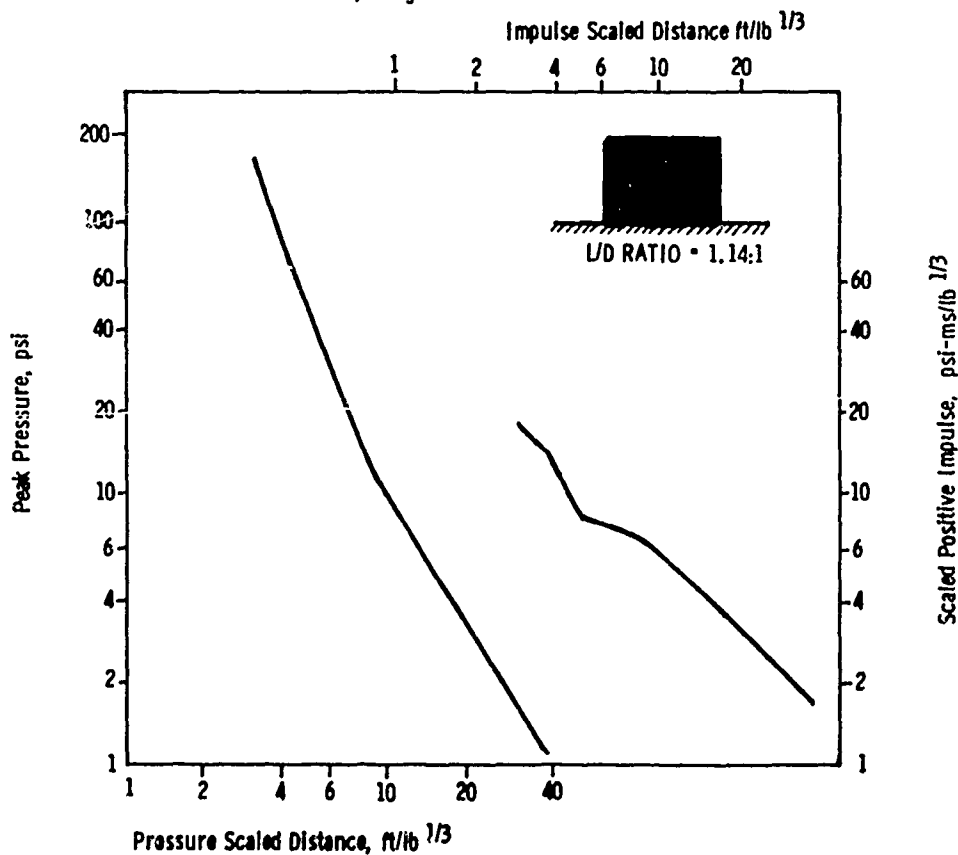
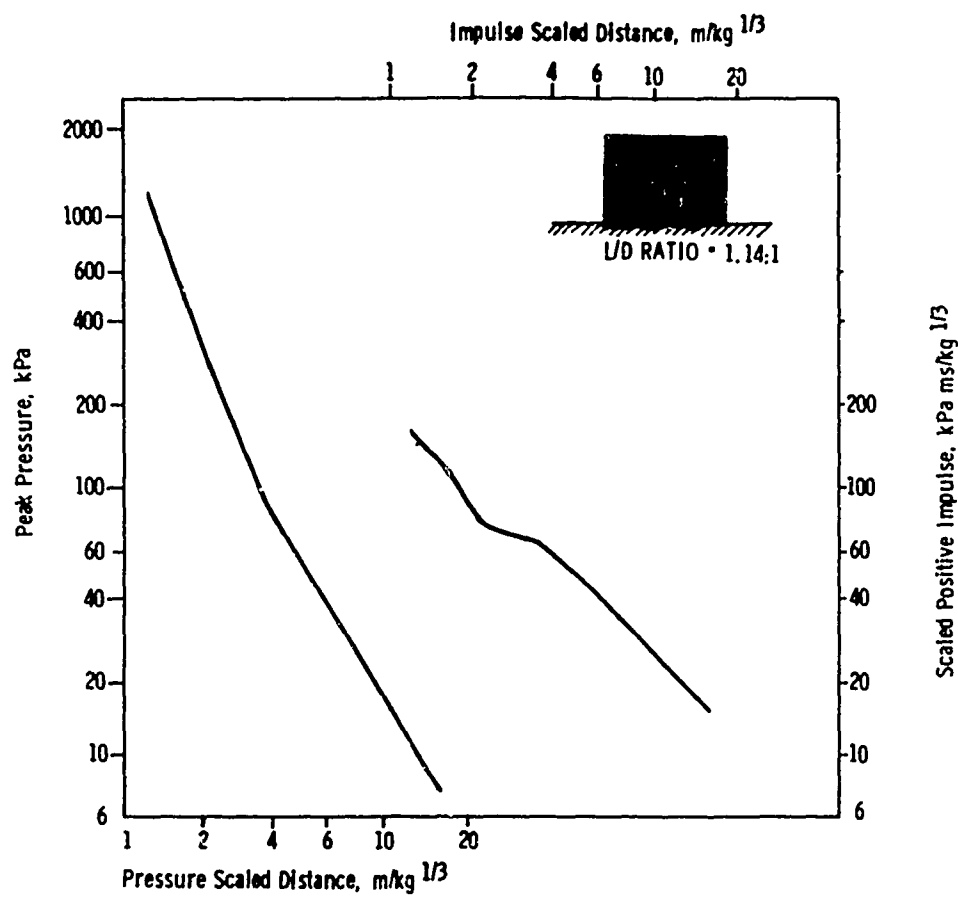


Figure 6. Pressure and Impulse vs. Scaled Distance 19.5 kg Charges

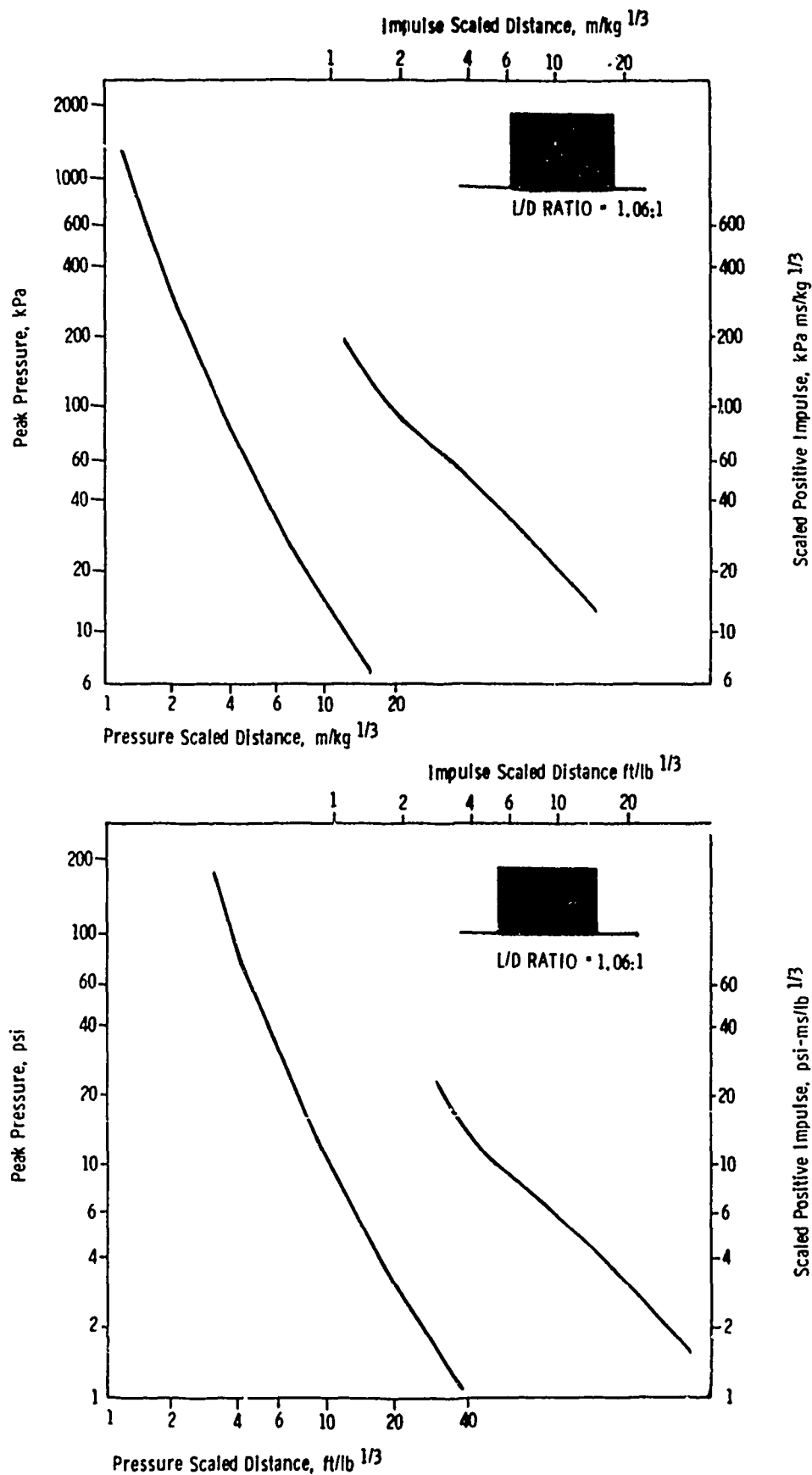


Figure 7. Pressure and Impulse vs. Scaled Distance 22.68 kg Charges

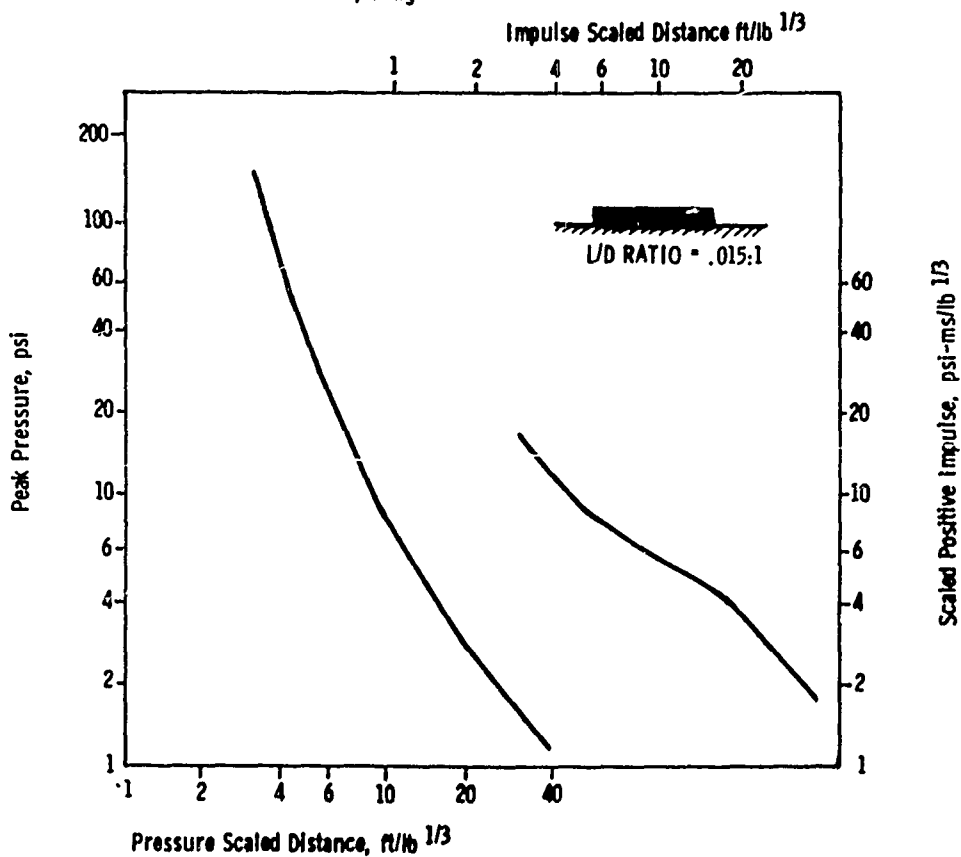
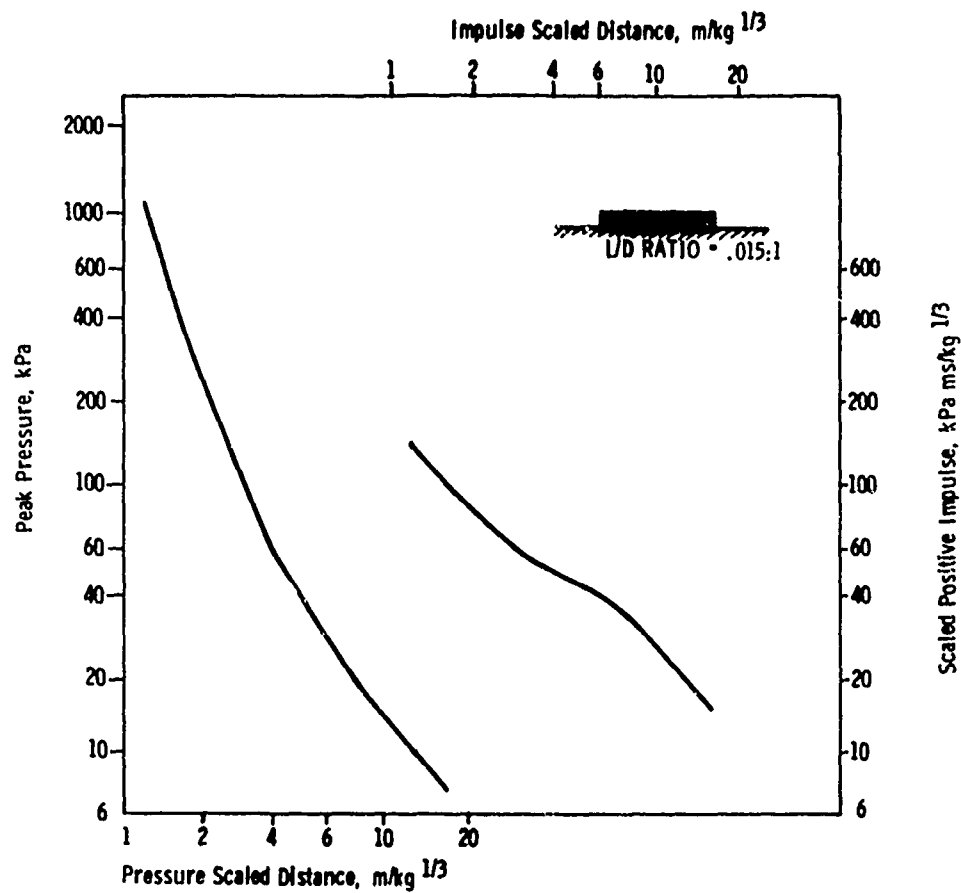


Figure 8. Pressure and Impulse vs. Scaled Distance 45 kg Charges

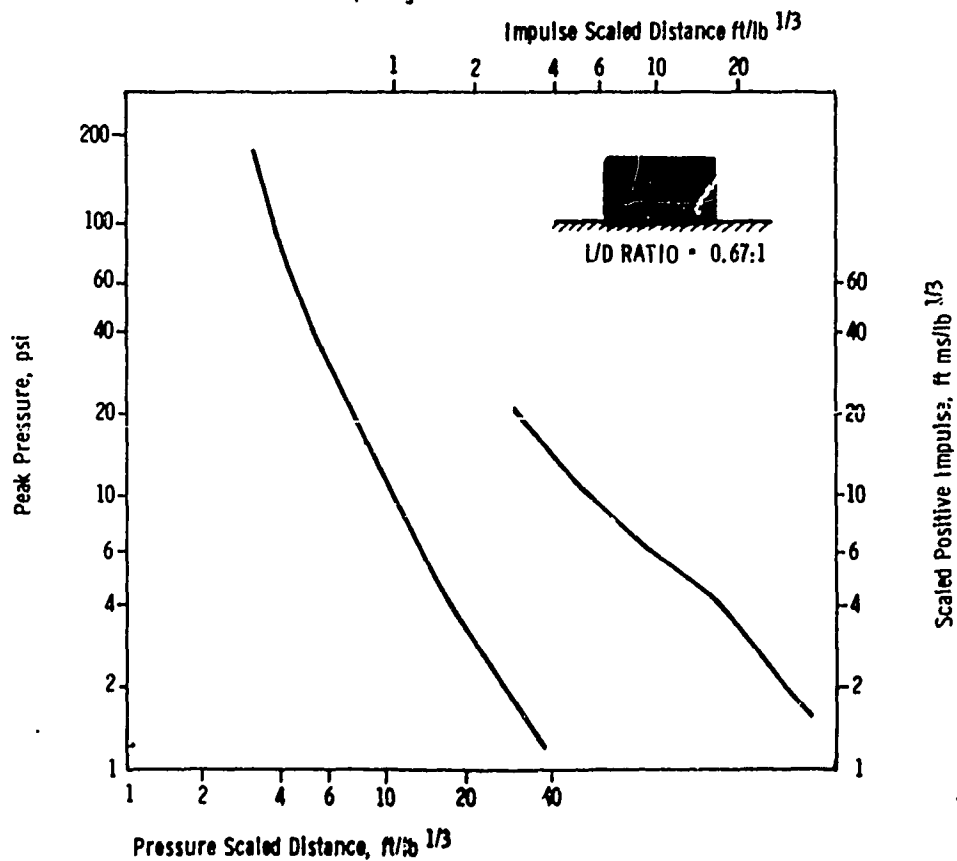
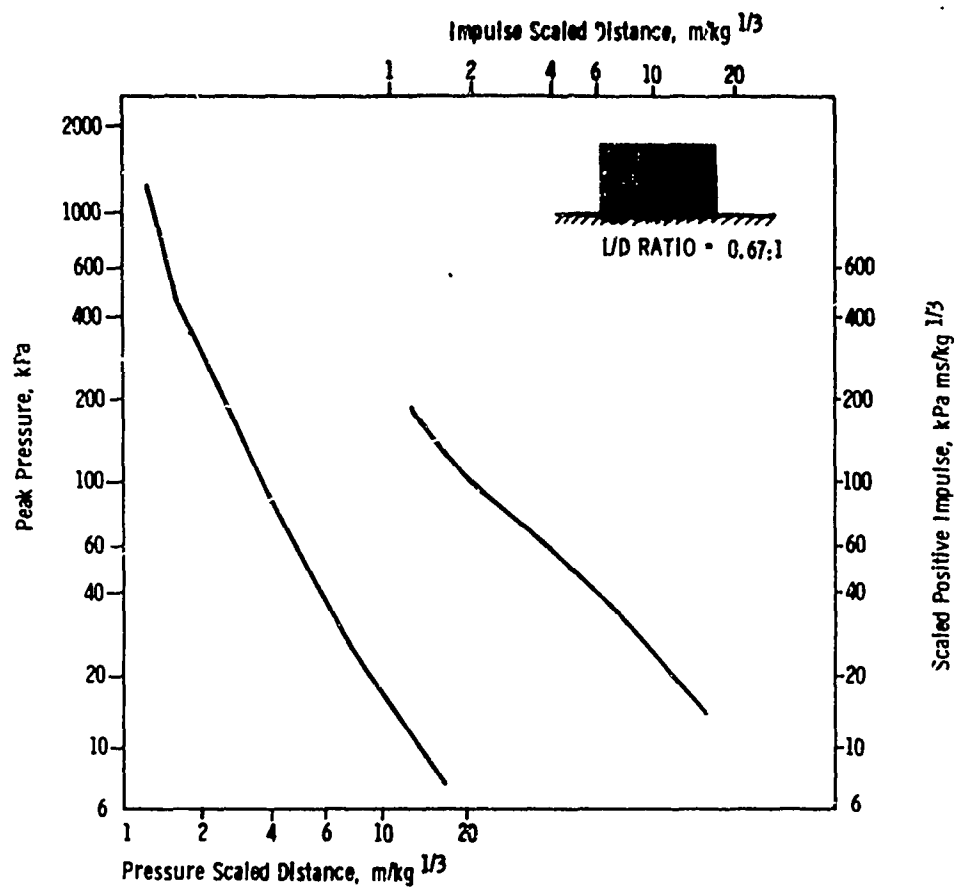


Figure 9. Pressure and Impulse vs. Scaled Distance 63.5 kg Charges



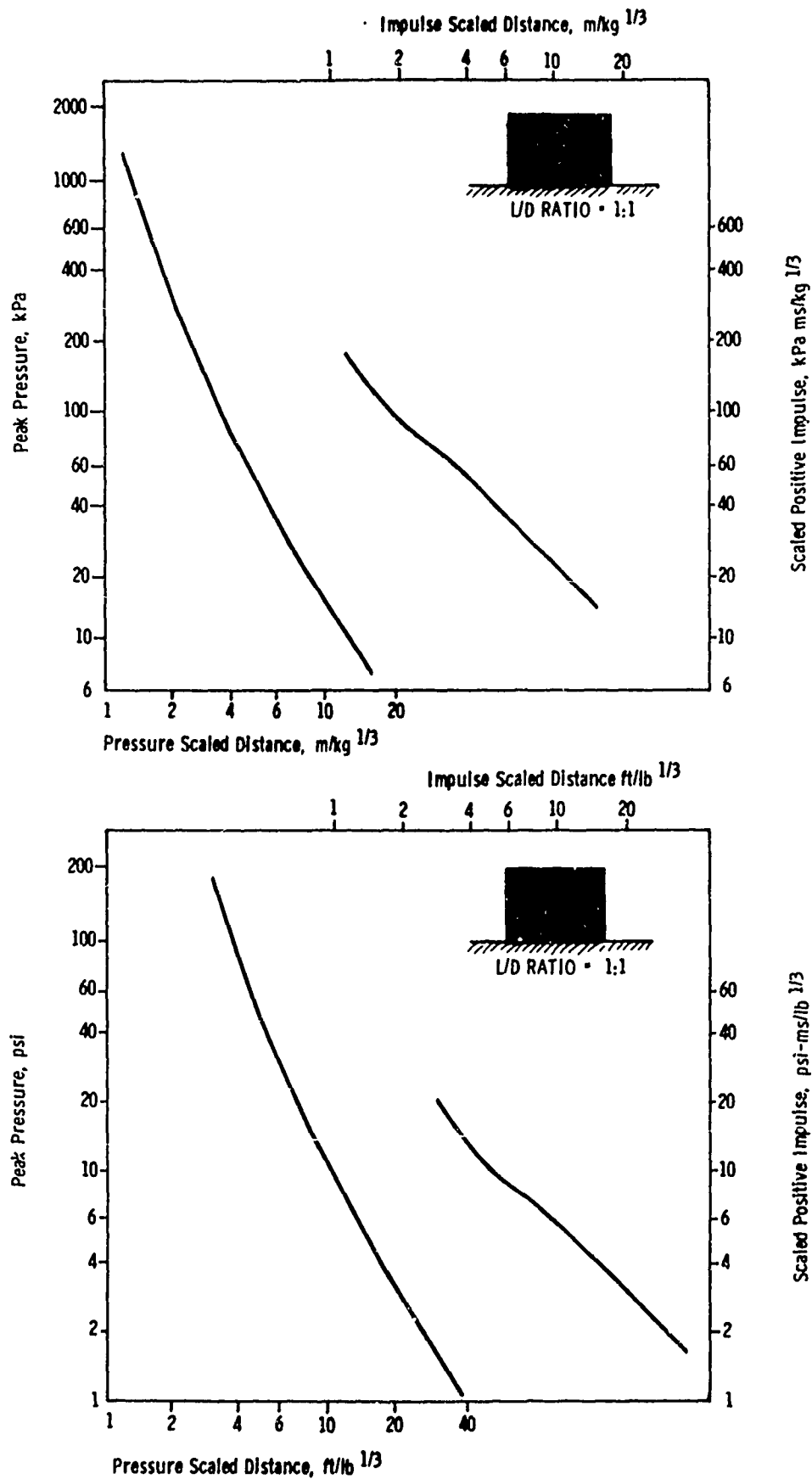


Figure 10. Pressure and Impulse vs. Scaled Distance for Combined Charge Weight with a Nominal L/D Ratio Approximately 1:1

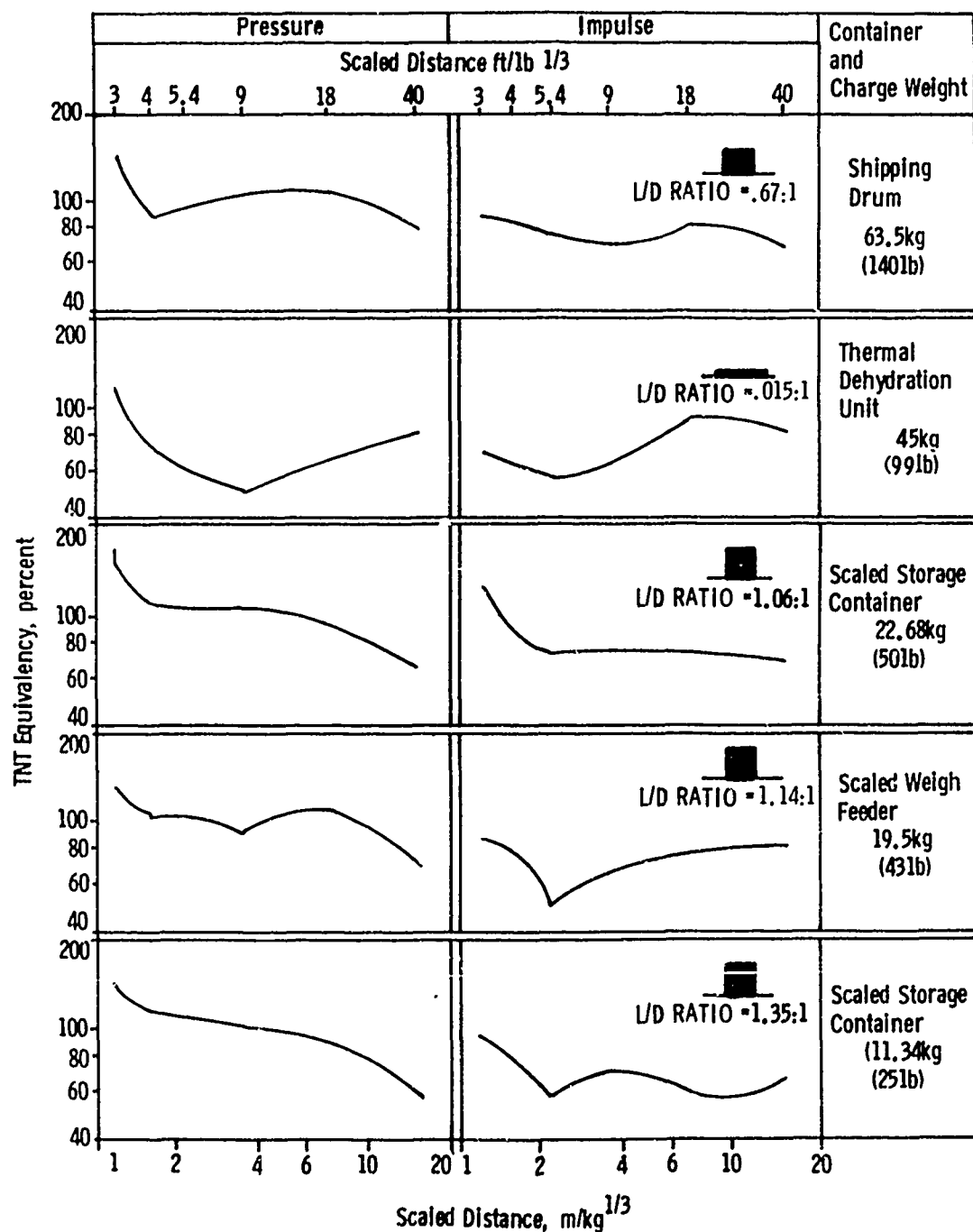


Figure 11. Pressure and Impulse Equivalencies

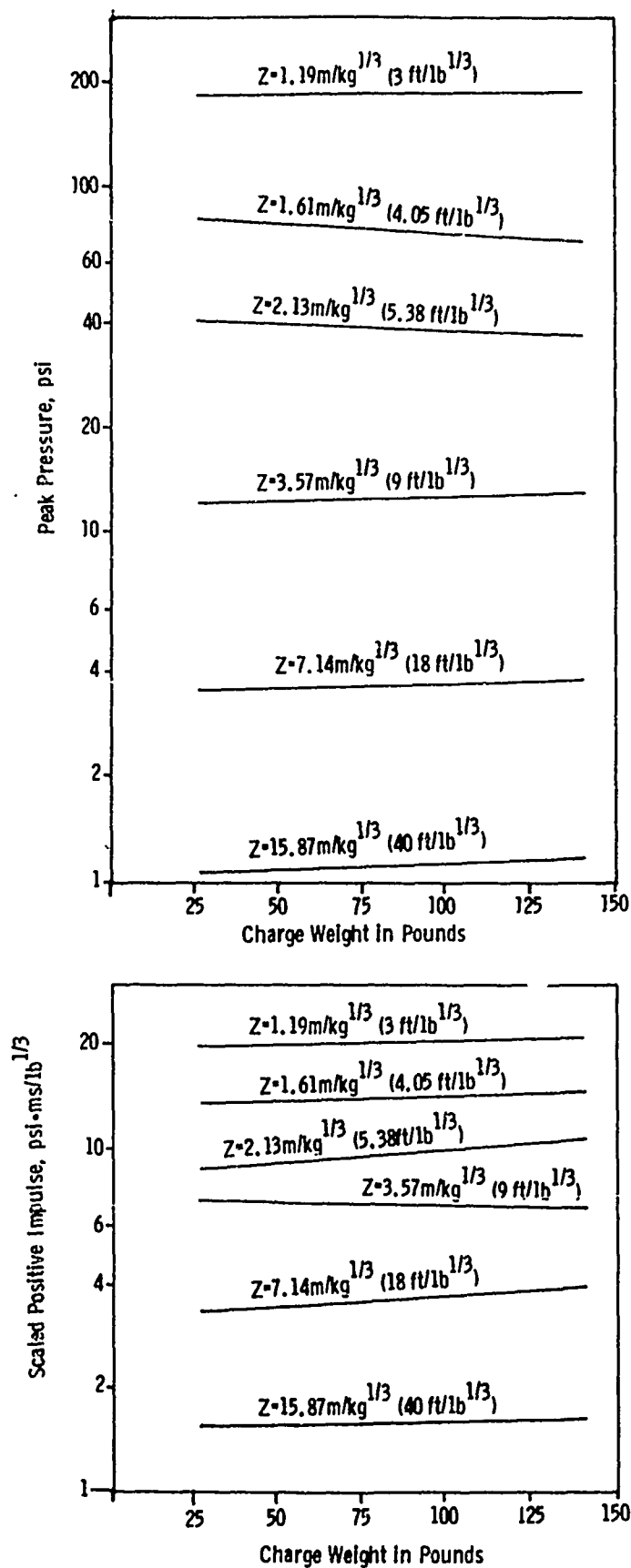


Figure 12. Deviation from Cube-Root Scaling of Nitrocellulose with an L/D Ratio Greater Than 1:1

Examination of the pressure and impulse data obtained from the 11.34, 19.5, 22.68 and 63.5 kg having similar L/D ratios indicated that the corresponding values fit a single curve. The composite data are shown in table 7 and figure 10.

Figure 12 is a graphic presentation of the deviation from cube root scaling for the 11.34-, 19.5-, 22.68- and 63.5-kg charge weight for pressure and impulse. A positive slope indicates that increasing charge masses at constant scaled distances result in an increase in pressure or impulse equivalency. Conversely, a negative slope is indicative of a decrease in pressure or impulse equivalency for increased charge masses. Generally the pressure slopes were slightly negative with the exception of scaled distances of 3.57 and 15.87 m/kg<sup>1/3</sup> where these values scaled slightly positive with increasing charge weights. Impulse values scaled slightly positive with increasing charge weights. Both the slight negative slope for pressure and the slightly positive slope for scaled impulse were within experimental error of the standard TNT cube root scaling.

Time of arrival data is reported for individual test in each data sheet (see Appendix A) and in the Summary Tables 2 through 6. There was no attempt made to determine TNT equivalencies based upon arrival times. Rather, these were used to aid in determining the good and bad data.

Fireball diameter and duration information was taken from the movies and these data are summarized in table 8. They are reported as information only as there is no reference to effectively gauge the significance.

TABLE 8 FIREBALL DURATION AND DIAMETER

Charge Weight kg (lb)	Maximum Fireball Diameter meters (ft)	Fireball Duration msec
11.34 (25)	10.4 (34)	274
19.5 (43)	13.1 (43)	278
22.68 (50)	14.02 (46)	402
45 (99)	18.9 (62)	415

## CONCLUSIONS

(1) TNT equivalency values of nitrocellulose in three in-plant situations were found to have pressure equivalencies greater than 100% for the near field values ( $Z \leq 6 \text{ m/kg}^{1/3}$ ) and less than 100% for the far field values ( $Z > 6 \text{ m/kg}^{1/3}$ ). Impulse equivalencies were generally less than 100% at all scaled distances. This was true for charge weights of 11.34, 19.5, 22.68 and 63.5 kg with a nominal L/D ratio of 1:1.

(2) Within the limits of the experiments, blast pressures and impulse scaled as a cube root function of the charge weights with test charges of a nominal L/D ratio of 1:1.

(3) TNT equivalency values of nitrocellulose under simulated conditions found in the Thermal Dehydration Unit were generally less than 100% for pressure and scaled impulse. The exceptions were at the near field value of  $1.19 \text{ m/kg}^{1/3}$  where the pressure equivalency was 130%, and the far field value of  $7.14 \text{ m/kg}^{1/3}$  where the impulse equivalency was 105%.

## RECOMMENDATION

The TNT equivalency of pressure and impulse values determined from this test series should be used, where applicable, in the structural design of protective facilities.

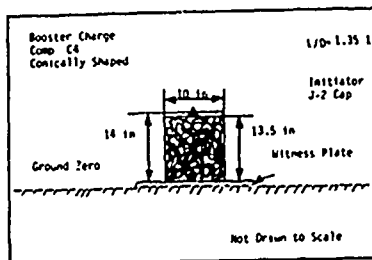
#### REFERENCES

1. Kingery, C. N., BRL Report No. 1344, Airblast Parameters Versus Distance for Hemispherical TNT Surface Bursts, September 1966.
2. KcKown, G. L., "TNT Equivalency of R284, I559, and I560 Tracer Composition," Technical Report ARLCD-TR-79026, ARRADCOM, Dover, NJ, October 1978.
3. Swatosh, J. J., and J. Cook, "TNT Equivalency of M1 Propellant (Bulk)," Technical Report 4885, Picatinny Arsenal, December 1975.
4. Wisotski, John and W. H. Syner, Characteristics of Blast Waves Obtained from Cylindrical High Explosive Charges, Denver Research Institute, November 1975.
5. McKown, G. L. and F. L. McIntyre, "TNT Equivalency of Composition A5," Technical Report ARLCD-TR-78018, ARRADCOM, Dover, NJ, March 1977.

## APPENDIX A

TEST DATA SHEETS, TNT EQUIVALENCY OF NITROCELLULOSE

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/15/78  
 TEST SAMPLE NITROCELLULOSE 14.5% ALCOHOL RIL-B-244A TIME 1118  
 SAMPLE WEIGHT 11.34kg (25 lb) TEMP 31.1°C (88°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 56%  
 BOOSTER WEIGHT 1.124g (2.5 lb) BAR. PRESS. 30.09  
 TEST NO. (33-B-02) WIND DIR 280°  
 CONTRACT NO. NAS13-50 WIND VEL. 2 knots

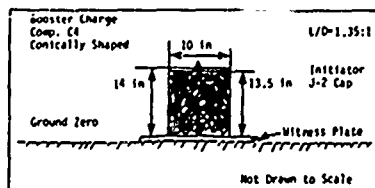


FIELD EVALUATION: Detonation occurred, clean hole in witness plate.  
 Photographic coverage: 1 documentary 24 fps, 1 high speed 500 fps motion picture and pre- and posttest still photos.

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST 11.34 kg ( 25 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (psi msec/ft <sup>1/3</sup> )	Time of Arrival msec	Remarks
1	2.67	1282.5 (186.01)	163.3 (10.2)	3.15	
2	( 8.77 )	1369.3 (198.6)	( — )	3.2	Bad Impulse Data
3	3.57	490.2 (71.09)	62.4 ( 8.95 )	4	
4	( 11.7 )	595.4 (86.36)	111.8 ( 12.46 )	4.1	
5	4.81	( — )	( — )	4.7	No Data "ader had loose connect.
6	(15.79)	283.8 (41.16)	85.3 ( 9.51 )	5.15	
7	8.02	87.2 (12.65)	51.2 ( 5.71 )	11.75	
8	(26.32)	69.6 (10.09)	55.6 ( 6.19 )	11.7	
9	16.04	29.8 (4.32)	36.5 ( 4.07 )	32.8	
10	(52.63)	22.8 (3.31)	28.8 ( 3.21 )	32.9	
11	35.66	7.17 (1.04)	13.7 (1.53)	86.6	
12	(117)	6.76 (0.98)	16.3 ( 1.82 )	86.55	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/15/78  
 TEST SAMPLE NITROCELLULOSE 14.5% ALCOHOL RIL-B-244A TIME 1219  
 SAMPLE WEIGHT 11.34kg (25 lb) TEMP. 32.8 (91°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 48%  
 BOOSTER WEIGHT 1.13kg (2.5 lb) BAR. PRESS. 37.68  
 TEST NO. A2 (33-B-03) WIND DIR 250°  
 CONTRACT NO. NAS13-50 WIND VEL. 5 knots



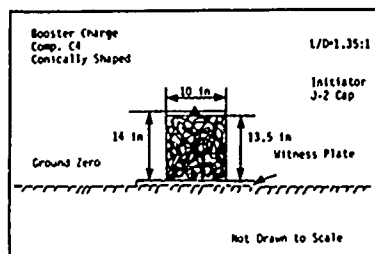
FIELD EVALUATION: Detonation, clean hole in witness plate

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST 11.34 kg ( 25 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (psi msec/ft <sup>1/3</sup> )	Time of Arrival msec	Remarks
1	2.67	1052.5 (152.65)	171.9 (19.16)	2.75	
2	( 8.77 )	1426.4 (206.88)	184.6 ( 20.57 )	2.7	
3	3.57	539.2 (78.2)	118.2 ( 13.17 )	3.75	
4	( 11.7 )	624.7 (90.61)	113.7 ( 12.67 )	3.7	
5	4.81	( — )	( — )	5.75	No Data Loose "ader connection
6	(15.79)	216.2 (31.36)	71.07 ( 7.92 )	5.35	
7	8.02	82.4 (11.98)	59.7 ( 6.65 )	12.45	
8	(26.32)	94.39 (13.69)	65.2 ( 7.26 )	12.35	
9	16.04	25.1 (3.35)	25.8 ( 2.87 )	32.5	
10	(52.63)	21.6 (3.13)	29.4 ( 3.28 )	32.4	
11	35.66	9.24 (1.34)	7.99 ( 0.89 )	85.9	
12	(117)	6.31 (0.92)	12.8 ( 1.43 )	86.1	

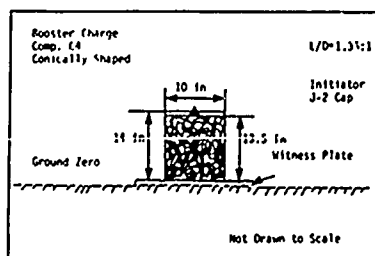


TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/15/78  
 TEST SAMPLE NITROCELLULOSE 14<sup>5</sup>SEALCOHOL MIL-R-244A TIME 1611  
 SAMPLE WEIGHT 11.34kg (25 lb) TEMP 33.3°C (92°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 45%  
 BOOSTER WEIGHT 1.13kg (2.5 lb) BAR. PRESS. 30.00  
 TEST NO A<sub>3</sub> (33-B-04) WIND DIR. 250°  
 CONTRACT NO. NAS13-50 WIND VEL. 8 knots



FIELD EVALUATION Detonation, clean hole in witness plate

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/15/78  
 TEST SAMPLE NITROCELLULOSE 14<sup>5</sup>SEALCOHOL MIL-R-244A TIME 1506  
 SAMPLE WEIGHT 11.34kg (25 lb) TEMP 33.3°C (92°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 43%  
 BOOSTER WEIGHT 1.13kg (2.5 lb) BAR. PRESS. 30.05  
 TEST NO A<sub>4</sub> (33-B-05) WIND DIR. 110°  
 CONTRACT NO. NAS13-50 WIND VEL. 1 knot



FIELD EVALUATION Detonation, clean hole in witness plate

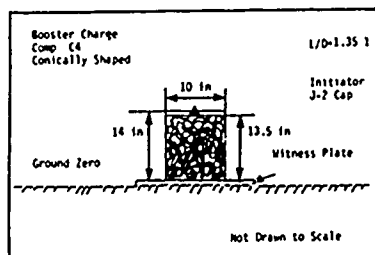
# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 11.34 kg ( 25 lb)					
Channel Number	Distance Meters (Fe)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (psi msec/ft <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	2.67 ( 8.77 )	1185.2 (171.90)	154.8 ( 17.25 )	2.3	
2		1350.3 (195.85)	152.6 ( 17.01 )	2.2	
3	3.57 ( 11.7 )	553.9 (80.33)	115.9 ( 12.91 )	3.4	
4		561.3 (81.41)	( — )	3.2	Ringing bad impulse data
5	4.81 ( 15.75 )	293.5 (42.57)	79.5 ( 8.86 )	5.2	
6		189.2 (27.44)	40.5 ( 4.51 )	5.0	
7	8.02 (26.32)	80.7 (11.71)	60.9 ( 6.79 )	11.8	
8		87.8 (12.73)	51.2 ( 5.82 )	11.8	
9	16.04 (52.63)	25.3 (3.67)	25.4 ( 2.83 )	32	
10		24.8 (3.59)	31.5 ( 3.51 )	32	
11	35.66 (117)	8 (1.16)	13.1 ( 1.46 )	85.55	
12		6.62 (0.96)	13.7 ( 1.53 )	85.75	

# EXPERIMENTAL RESULTS

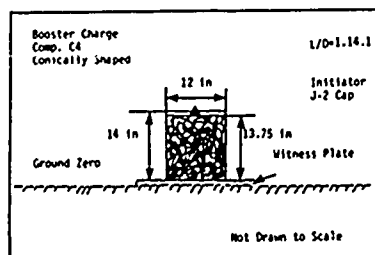
TNT EQUIVALENCY TEST: 11.34 kg ( 25 lb)					
Channel Number	Distance Meters (Fe)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (psi msec/ft <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	2.67 ( 8.77 )	1096.75 (159.07)	107.3 ( 11.96 )	2.9	
2		1378.8 (199.98)	183.3 ( 20.43 )	3.0	
3	3.57 ( 11.7 )	473.6 (68.25)	126.6 ( 14.11 )	3.9	
4		522.3 (75.75)	( — )	3.9	Bad Impulse Data
5	4.81 (15.79)	276.2 (40.06)	81.3 ( 9.06 )	6.0	
6		( — )	( — )	—	No Data
7	8.02 (26.32)	82.6 (11.98)	71.7 ( 7.99 )	12.65	
8		69.6 (10.09)	70.2 ( 7.82 )	12.4	
9	16.04 (52.63)	23.9 ( 3.46 )	2.64 ( 2.94 )	32.5	
10		22.4 ( 3.25 )	27.3 ( 3.04 )	32.65	
11	35.66 (117)	7.03 ( 1.02 )	12.7 ( 1.42 )	85.85	
12		( — )	( — )	86.0	No Data loose isder connection

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/16/78  
 TEST SAMPLE NITROCELLULOSE 14'SSALCONOL MIL-N-244A TIME 1052  
 SAMPLE WEIGHT 11.34kg (25 lb) TEMP 32.2°C (90°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 53%  
 BOOSTER WEIGHT 1.13kg (2.5 lb) BAR. PRESS 30.07  
 TEST NO AS (33-B-06) WIND DIR. 250°  
 CONTRACT NO NAS13-50 WIND VEL 3 knots



FIELD EVALUATION Detonation, clean hole in witness plate

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 3/25/78  
 TEST SAMPLE NITROCELLULOSE 14'SSALCONOL MIL-N-244A TIME 1050  
 SAMPLE WEIGHT 19.5kg (43 lb) TEMP 32.8°C (91°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 36%  
 BOOSTER WEIGHT 1.95kg (4.3 lb) BAR. PRESS 30.08  
 TEST NO 81 (34-B-05) WIND DIR. 60°  
 CONTRACT NO NAS13-50 WIND VEL 13 knots



FIELD EVALUATION Detonation, clean hole in witness plate

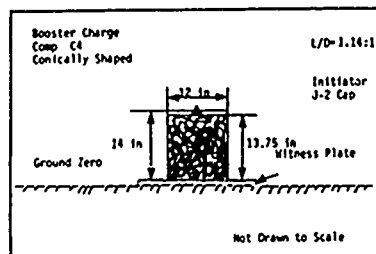
# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST 11.34 kg ( 25 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg <sup>1/3</sup> (psi msec/lb <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	2.67	882.3 (127.97)	92.3 (10.29)	3.4	
2	( 8.77 )	855.8 (124.12)	181.7 (20.25)	3.4	
3		509.7 (73.93)	72.7 ( 8.1 )	4.3	
4	( 11.7 )	759.7 (110.18)	121.9 (13.58)	4.3	
5		285.8 (41.45)	88.7 ( 9.88 )	6.15	
6	(15.79)	244.8 (35.51)	70.3 ( 7.83 )	6.25	
7		76.2 (11.05)	50.3 ( 5.6 )	12.75	
8	(26.32)	89.22 (12.94)	54.1 ( 6.03 )	12.85	
9		25.4 ( 3.64 )	27.7 ( 3.09 )	32.8	
10	(52.63)	22.6 ( 3.28 )	26.7 ( 2.97 )	33	
11		7.03 ( 1.02 )	15.2 ( 1.69 )	86.45	
12	(117)	6.69 ( 0.97 )	8.7 ( 0.97 )	86.6	

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST 19.5 kg ( 43 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg <sup>1/3</sup> (psi msec/lb <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1		625.9 (90.78)	147.9 (16.48)	3.6	
2	( 10.51 )	1,027.8 (146.32)	159.1 (17.73)	3.7	
3		343.57 (49.83)	79.7 ( 8.88 )	4.7	
4	( 14.19 )	435.9 (63.22)	126.1 (14.05)	5.0	
5		212.4 (30.81)	40.5 ( 4.52 )	7.2	
6	(18.84)	214.8 (31.16)	52.3 ( 5.82 )	7.15	
7		89.9 (12.9)	48.9 ( 5.45 )	15.85	
8	( 31.53 )	101.4 (14.7)	63 ( 7.02 )	15.55	
9		29.8 ( 4.32 )	34.1 ( 3.80 )	41.2	
10	( 43.06 )	( — )	( — )	—	No data from recorder
11		7.4 ( 1.07 )	15.9 ( 1.77 )	108.75	
12	(42.71 (140.14)	6.81 ( 0.98 )	16.7 ( 1.86 )	108.1	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/25/78  
 TEST SAMPLE NITROCELLULOSE 14-55 ALCOXOL MIL-W-244A TIME 1805  
 SAMPLE WEIGHT 19.54g (43 lb) TEMP 35°C (95°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 33%  
 BOOSTER WEIGHT 1.951g (4.3 lb) BAR. PRESS. 30.04  
 TEST NO. 82 (34-B-06) WIND DIR. 10°  
 CONTRACT NO. WAS13-50 WIND VEL. 1 knot

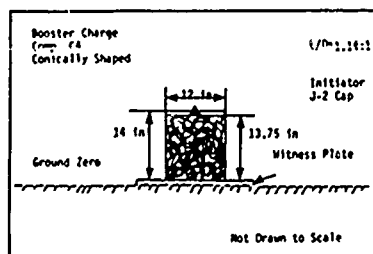


FIELD EVALUATION: Detonation occurred, clean hole in witness plate motion picture and still photographs taken.

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 19.5 kg ( 43 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg <sup>1/3</sup> (psi msec/lb <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	3.2	920.5 (133.5)	147.7 (16.46)	2.5	
2	( 10.51 )	1437.1 (208.43)	189.6 (21.13)	2.45	
3	4.33	625.9 (90.78)	104.7 (11.67)	3.65	
4	( 14.19 )	653.8 (94.83)	42.3 (4.71)	3.65	
5	5.74	265.5 (38.51)	8.54 (9.52)	5.55	
6	( 18.84 )	280.3 (40.65)	74.5 (8.3)	5.55	
7	9.61	92.5 (13.41)	114.3 (12.74)	13.7	
8	(31.53)	65.4 (9.48)	100.4 (11.19)	13.45	
9	19.22	26.1 (3.78)	31.1 (3.47)	37.2	
10	( 63.06 )	25.2 (3.65)	32.8 (3.66)	37.2	
11	42.71	7.24 (1.05)	16.1 (1.79)	100.8	
12	(140.14)	7.72 (1.12)	17.4 (1.94)	101.3	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/25/78  
 TEST SAMPLE NITROCELLULOSE 14-55 ALCOXOL MIL-W-244A TIME 1524  
 SAMPLE WEIGHT 19.54g (43 lb) TEMP 34.4°C (94°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 46%  
 BOOSTER WEIGHT 1.951g (4.3 lb) BAR. PRESS. 30.02  
 TEST NO. 82 (34-B-07) WIND DIR. 50°  
 CONTRACT NO. WAS13-50 WIND VEL. 7 knots

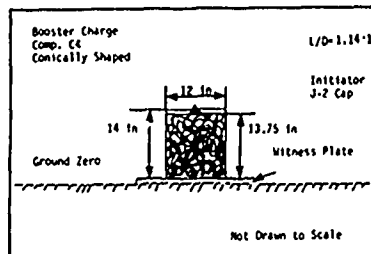


FIELD EVALUATION: Detonation, clean hole in witness plate

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 19.5 kg ( 43 lb) 8					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg <sup>1/3</sup> (psi msec/lb <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	3.2	( — )	( — )	—	
2	( 10.51 )	1153.4 (167.29)	176.8 (19.7)	3.0	
3	4.33	400 (58.02)	110.7 (12.34)	4.05	
4	(14.19)	544.9 (79.03)	144.2 (16.07)	4.25	
5	5.74	( — )	( — )	—	No useable data
6	(18.84)	242.9 (35.23)	52.9 (5.89)	6.45	
7	9.61	92.5 (13.41)	98.1 (10.93)	14.1	
8	(31.53)	101.4 (14.7)	51.9 (5.78)	14.2	
9	19.22	26.9 (3.9)	35.99 (4.01)	38.1	
10	( 63.06 )	21.96 (3.23)	33.5 (3.73)	38.35	
11	42.71	7.83 (1.13)	13.5 (1.5)	101.7	
12	(140.14)	7.72 (1.12)	12.3 (1.37)	102.6	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/28/78  
 TEST SAMPLE NITROCELLULOSE 1455 ALCOHOL MIL-N-244A TIME 1109  
 SAMPLE WEIGHT 19.5kg (43 lb) TEMP. 29.4°C (85°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 64%  
 BOOSTER WEIGHT 1.95kg (4.3 lb) BAR. PRESS. 29.94  
 TEST NO. B<sub>2</sub> (35-B-02) WIND DIR. 130°  
 CONTRACT NO. NAS13-50 WIND VEL. 10 knots

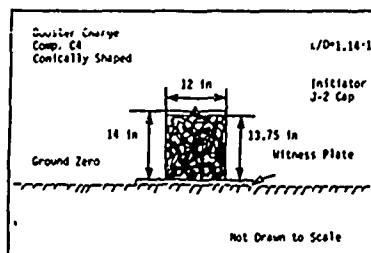


FIELD EVALUATION: Detonation, clean hole in witness plate

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 19.5 kg (43 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (ft-lb sec/ft <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	3.2	1242.4 (183.09)	142.2 (18.07)	2.6	
2	(10.51)	1481.1 (214.02)	113.2 (12.61)	2.6	
3	4.33	494.4 (71.7)	110.6 (12.32)	3.7	
4	(14.19)	449.4 (65.18)	120.8 (13.46)	3.65	
5	5.74	290.8 (42.17)	33.4 (3.72)	5.6	
6	(18.04)	309.9 (44.95)	127.3 (14.91)	5.5	
7	9.61	65.8 (9.55)	12.8 (1.43)	12.6	
8	(31.53)	(11.19)	60.5 (6.74)	13.3	
9	19.22	77.2 (11.19)	( )		No useable Data
10	(63.06)	24.4 (3.54)	( )	37.4	Bad impulse Data
11	42.71	8.96 (1.3)	15.8 (1.76)	101.3	
12	(140.14)	( )	( )		No Data

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/28/78  
 TEST SAMPLE NITROCELLULOSE 1455 ALCOHOL MIL-N-244A TIME 1015  
 SAMPLE WEIGHT 19.5kg (43 lb) TEMP. 30°C (86°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 64%  
 BOOSTER WEIGHT 1.95kg (4.3 lb) BAR. PRESS. 29.94  
 TEST NO. B<sub>2</sub> (35-B-0) WIND DIR. 130°  
 CONTRACT NO. NAS13-50 WIND VEL. 17 knots

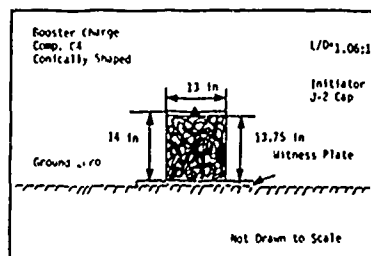


FIELD EVALUATION: Detonation, clean hole in witness plate

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 19.5 kg (43 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/ft <sup>1/3</sup> (ft-lb sec/ft <sup>1/3</sup> )	Time of Arrival (msec)	Remarks
1	3.2	1244.6 (180.51)	133.8 (14.58)	3.4	
2	(10.51)	1044.4 (151.48)	182.1 (20.29)	3.4	
3	4.33	655.9 (95.14)	135.3 (15.08)	4.25	
4	(14.19)	851.5 (123.50)	120.4 (13.44)	4.6	
5	5.74	468.98 (67.02)	85.5 (9.53)	5.6	
6	(18.04)	332.1 (48.16)	86.2 (9.61)	6.05	
7	9.61	61.21 (8.88)	31.1 (3.46)	12.7	
8	(31.53)	67.1 (9.73)	82.8 (9.23)	14.25	
9	19.22	( )	35.5 (3.95)	38.35	
10	(63.06)	27.03 (3.92)	( )	38.8	Bad impulse Data
11	42.71	( )	( )	102.1	Bad Data
12	(140.14)	24.41 (3.54)	5.2 (0.57)	102.45	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/17/78  
 TEST SAMPLE NITROCELLULOSE 1455 ALCOHOL MIL-H-244A TIME 1214  
 SAMPLE WEIGHT 22.68kg (50 lb) TEMP. 33.9°C (93°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 49%  
 BOOSTER WEIGHT 2.27kg (5 lb) BAR. PRESS 30.02  
 TEST NO. C<sub>1</sub> (33-8-08) WIND DIR. 260°  
 CONTRACT NO. NAS13-50 WIND VEL. 5 knots

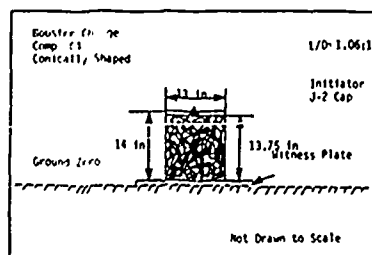


FIELD EVALUATION Detonation occurred, hole in witness plate

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST- 22.68 kg ( 50 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/10 1/3 (psi msec/10 1/3)	Time of Arrival (msec)	Remarks
1	3.37 (11.05)	1834.3 (266.04)	221.1 (24.64)	3.4	
2		1522.9 (220.89)	207.6 (23.13)	3.4	
3		836.6 (121.34)	174.1 (19.4)	4.5	
4	4.49 (14.74)	531.9 (77.14)	131.92 (14.7)	4.6	
5	6.06 (19.89)	414.2 (60.07)	95.75 (10.67)	6.6	
6		325.7 (47.24)	99.97 (11.14)	6.75	
7		97.5 (14.14)	64.6 (7.2)	15.1	
8	10.11 (33.2)	84.4 (12.24)	68.5 (7.63)	15.15	
9		25.7 (3.72)	37.1 (4.13)	39.9	
10	20.23 (66.3)	26.4 (3.83)	30.6 (3.41)	40.2	
11		7.52 (1.09)	14 (1.56)	107.4	
12	44.92 (147.4)	9.03 (1.31)	17.95 (2.0)	107.8	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/17/78  
 TEST SAMPLE NITROCELLULOSE 1455 ALCOHOL MIL-H-244A TIME 1435  
 SAMPLE WEIGHT 22.68kg (50 lb) TEMP. 35.6°C (96°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 42%  
 BOOSTER WEIGHT 2.27kg (5 lb) BAR. PRESS. 29.96  
 TEST NO. C<sub>2</sub> (33-8-09) WIND DIR. 115°  
 CONTRACT NO. NAS13-50 WIND VEL. 3 knots

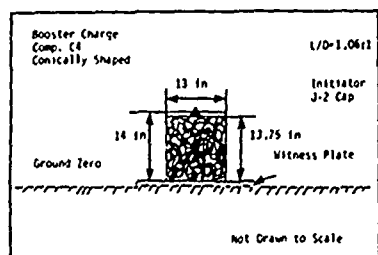


FIELD EVALUATION Detonation occurred, no hole in witness plate due to stand off

# EXPERIMENTAL RESULTS

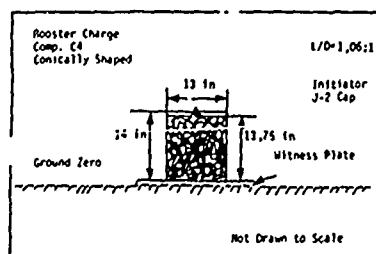
TNT EQUIVALENCY TEST- 22.68 kg ( 50 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/10 1/3 (psi msec/10 1/3)	Time of Arrival (msec)	Remarks
1	3.37 (11.05)	1315.5 (190.8)	199.8 (22.26)	2.15	
2		1427.8 (207.09)	205.4 (22.89)	2.15	
3		612.9 (88.89)	142.8 (15.91)	3.5	
4	4.49 (14.74)	396.5 (57.51)	117.1 (13.05)	3.0	
5	6.06 (19.89)	396.5 (57.51)	72.7 (8.1)	5.45	
6		262.48 (38.07)	95.2 (10.6)	5.4	
7		102.8 (14.91)	50.2 (5.49)	13.8	
8	10.11 (33.2)	97.4 (14.12)	63.98 (7.13)	14.0	
9		27.1 (3.92)	33.3 (3.71)	38.8	
10	20.21 (66.3)	23.5 (3.41)	30.1 (3.35)	39.1	
11		7.52 (1.09)	14.99 (1.67)	106.1	
12	44.92 (147.4)	8.48 (1.23)	15.97 (1.78)	106.7	

TEST TITLE: TNT EQUIVALENCY NITROCELLULOSE DATE: 8/17/78  
 TEST SAMPLE: NITROCELLULOSE 14-5EALCONOL MIL-N-244A TIME: 1543  
 SAMPLE WEIGHT: 22.68kg (50 lb) TEMP: 33.3°C (92°F)  
 IGNITION SOURCE: J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY: 60%  
 BOOSTER WEIGHT: 2.27kg (5 lb) BAR. PRESS: 29.96  
 TEST NO: C<sub>1</sub> (33-B-10) WIND DIR: 145°  
 CONTRACT NO: NAS13-50 WIND VEL: 6 knots



FIELD EVALUATION: Detonation occurred

TEST TITLE: TNT EQUIVALENCY NITROCELLULOSE DATE: 8/18/78  
 TEST SAMPLE: NITROCELLULOSE 14-5EALCONOL MIL-N-244A TIME: 1015  
 SAMPLE WEIGHT: 22.68kg (50 lb) TEMP: 32.8°C (91°F)  
 IGNITION SOURCE: J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY: 55%  
 BOOSTER WEIGHT: 2.27kg (5 lb) BAR. PRESS: 29.99  
 TEST NO: C<sub>1</sub> (33-B-11) WIND DIR: 255°  
 CONTRACT NO: NAS13-50 WIND VEL: 2 knots



FIELD EVALUATION: Detonation occurred

# EXPERIMENTAL

# RESULTS

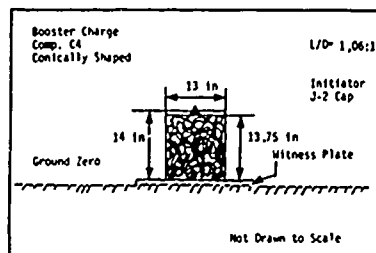
TNT EQUIVALENCY TEST: 22.68 kg ( 50 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	3.37 ( 11.05 )	1260 (182.74)	206.4 ( 23 )	3.4	
2		1275.5 (184.99)	182.9 ( 20.38 )	3.4	
3	4.49 ( 14.74 )	583.7 (84.66)	118.7 ( 13.23 )	4.45	
4		560.9 (81.35)	122.8 ( 13.68 )	4.6	
5	6.06 (19.89)	220.3 (31.95)	92.9 (10.35)	6.5	
6		262.5 (38.07)	86.1 ( 9.59 )	7	
7	10.11 ( 33.2 )	79.7 (11.56)	50.9 ( 5.68 )	15.5	
8		81.2 (11.77)	57.5 ( 6.41 )	15.5	
9	20.21 ( 66.3 )	22.8 ( 3.31 )	32.6 ( 3.74 )	40.8	
10		23.5 ( 3.41 )	29.7 ( 3.31 )	40.4	
11	44.92 (147.4)	6.62 ( 0.96 )	13.01 ( 1.45 )	108.3	
12		7.93 ( 1.15 )	15.88 ( 1.77 )	107.8	

# EXPERIMENTAL

# RESULTS

TNT EQUIVALENCY TEST: 22.68 kg ( 50 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	3.37 ( 11.05 )	1156 (167.66)	173.7 ( 19.36 )	3.5	
2		1337.1 (193.92)	196.9 ( 21.94 )	3.4	
3	4.49 ( 14.74 )	445.1 (64.56)	143.1 ( 15.95 )	4.45	
4		460.6 (66.8)	115.3 ( 12.85 )	4.7	
5	6.06 (19.89)	(---)	(---)	---	No Data
6		22.9 ( 3.32 )	71.8 ( 8.00 )	7	
7	10.11 ( 33.2 )	90 (13.05)	56.1 ( 6.25 )	15.8	
8		84.5 (12.25)	61.2 ( 6.82 )	15.6	
9	20.21 ( 66.3 )	24.5 ( 3.55 )	33.5 ( 3.73 )	41.1	
10		22.9 ( 3.32 )	26.7 ( 2.97 )	41.2	
11	44.92 (147.4)	7.17 ( 1.04 )	12.65 ( 1.41 )	108.8	
12		6.21 ( 0.9 )	13.46 ( 1.5 )	108.95	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/18/78  
 TEST SAMPLE NITROCELLULOSE 14-SKALCONOL MIL-N-244A TIME 1227  
 SAMPLE WEIGHT 22.68 kg (50 lb) TEMP. 33.9°C (93°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 47%  
 BOOSTER WEIGHT 2.27 kg (5 lb) BAR. PRESS. 29.99  
 TEST NO. C<sub>5</sub> (33-B-12) WIND DIR. 225°  
 CONTRACT NO. NAS13-50 WIND VEL. 6 knots



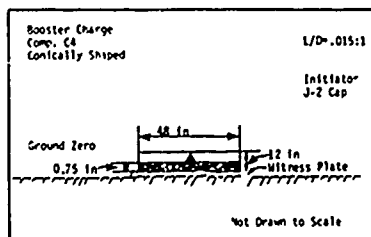
FIELD EVALUATION: Detonation occurred.

#### EXPERIMENTAL

#### RESULTS

TNT EQUIVALENCY TEST 22.68 kg (50 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1		( )	( )	—	No Data
2	4.37 (14.35)	1146.3 (166.23)	294.4 (32.8)	2.3	
3		563.9 (81.78)	124.4 (13.59)	3.2	
4	4.49 (14.74)	590.1 (85.59)	72.9 (8.13)	3.55	
5		( )	( )	—	No Data
6	6.06 (19.89)	286.1 (41.5)	80.7 (8.99)	5.8	
7		93.6 (13.57)	25.9 (2.89)	13.8	
8	10.31 (33.8)	71.4 (10.34)	107.5 (11.98)	14.15	
9		24.5 (3.55)	35.9 (4)	39.1	
10	20.21 (66.3)	20.6 (2.99)	29.8 (3.32)	39.7	
11		7.03 (1.02)	12.47 (1.39)	106.6	
12	44.92 (147.4)	6.21 (0.9)	19.92 (2.22)	107.2	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/29/78  
 TEST SAMPLE NITROCELLULOSE 1-0 S<sub>1</sub> ALCONOL MIL-N-244A TIME 1532  
 SAMPLE WEIGHT 45 kg (99 lb) TEMP. 24.6°C (76°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 99%  
 BOOSTER WEIGHT 5.26 kg (11.6 lb) BAR. PRESS. 29.84  
 TEST NO. D<sub>1</sub> (35-B-03) WIND DIR. 220°  
 CONTRACT NO. NAS13-50 WIND VEL. 0 k



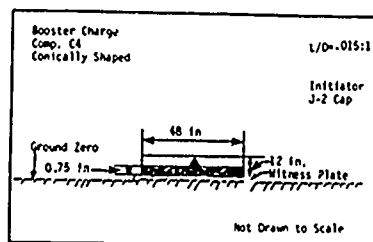
FIELD EVALUATION: Detonation occurred no hole in witness plate due to the stand off. Still photographs of pretest and posttest taken. 500 fps and 24 fps motion picture film taken.

#### EXPERIMENTAL

#### RESULTS

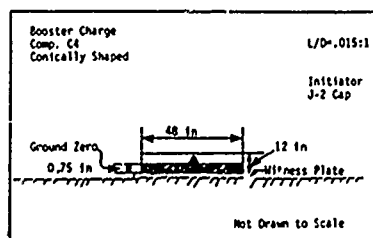
TNT EQUIVALENCY TEST 45 kg (99 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/kg 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1		1526.1 (221.34)	139.6 (15.56)	3.6	
2	4.46 (14.63)	999.7 (144.99)	143.7 (16.03)	4.15	
3		624.9 (90.63)	115.3 (12.85)	5.4	
4	6.02 (19.75)	340.6 (49.4)	114.1 (12.71)	6.2	
5		276.2 (40.04)	83.6 (9.31)	8.55	
6	8 (26.24)	224 (31.04)	79.3 (8.84)	9.85	
7		64 (9.28)	55.1 (6.14)	20.2	
8	13.38 (43.89)	74.9 (10.86)	55.3 (6.16)	21.8	
9		16.9 (2.45)	( )	55.55	Bad Impulse Data
10	26.76 (87.79)	19.2 (2.78)	32.7 (3.64)	56.9	
11		7.31 (1.06)	( )	146.4	Bad Impulse Data
12	59.46 (195.08)	7.65 (1.11)	16.51 (1.84)	147.4	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/31/78  
 TEST SAMPLE NITROCELLULOSE 1-0.5% ALCOHOL MIL-N-244A TIME 1435  
 SAMPLE WEIGHT 45 kg (99 lb) TEMP. 26.1°C (78°F)  
 IGNITION SOURCE 32 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 83%  
 BOOSTER WEIGHT 5.26 kg (11.6 lb) BAR. PRESS. 29.93  
 TEST NO D<sub>2</sub> (35-B-04) WIND DIR. 115°  
 CONTRACT NO. MAS13-50 WIND VEL 3 knots



FIELD EVALUATION: Detonation occurred, no hole in witness plate

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 9/1/78  
 TEST SAMPLE NITROCELLULOSE 1-0.5% ALCOHOL MIL-N-244A TIME 1120  
 SAMPLE WEIGHT 45 kg (99 lb) TEMP. 31.7°C (89°F)  
 IGNITION SOURCE 23 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 45%  
 BOOSTER WEIGHT 5.26 kg (11.6 lb) BAR. PRESS. 30.01  
 TEST NO D<sub>1</sub> (35-B-05) WIND DIR. 300°  
 CONTRACT NO. MAS13-50 WIND VEL 6 knots



FIELD EVALUATION: Detonation occurred, no hole in witness plate

# EXPERIMENTAL RESULTS

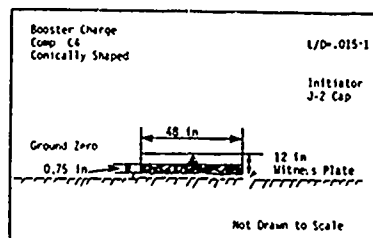
TNT EQUIVALENCY TEST: 45 kg (99 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	4.46 (14.63)	608.5 (88.25)	128.2 (14.28)	4.3	
2		592.1 (85.88)	128.4 (14.31)	4.8	
3	6.02 (19.75)	300 (43.51)	88 (9.81)	6.5	
4		244.9 (38.42)	57.2 (6.37)	7.1	
5	8 (26.24)	192 (27.85)	( — )	10.45	Bad Impulse Data
6		187.2 (27.15)	( — )	11.25	Bad Impulse Data
7	13.38 (43.89)	50.7 (7.35)	43.6 (4.86)	22.8	
8		41.8 (6.96)	56.4 (6.28)	23.4	
9	26.76 (87.78)	25 (3.78)	36.4 (4.06)	57.3	
10		22.3 (3.24)	32.8 (3.66)	57.7	
11	59.46 (195.08)	8.42 (1.25)	14.72 (1.64)	146.75	
12		7.38 (1.07)	14 (1.56)	147.1	

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 45 kg (99 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	4.46 (14.63)	1167 (169.20)	164.4 (18.32)	2.2	
2		1372.2 (199.02)	160.5 (17.88)	2.4	
3	6.02 (19.75)	515.1 (74.71)	106.3 (11.84)	3.8	
4		605.5 (87.82)	97.8 (10.9)	4.1	
5	8 (26.24)	( — )	74.5 (8.3)	6.6	
6		190.6 (27.65)	( — )	7.1	Bad Impulse Data
7	13.38 (43.89)	38.1 (5.53)	( — )	18.8	Bad Impulse Data
8		67.2 (9.75)	61.9 (6.9)	19.8	
9	26.76 (87.78)	20.1 (2.91)	37.4 (4.17)	53.6	
10		17.9 (2.6)	35.7 (3.98)	54.25	
11	59.46 (195.08)	8.34 (1.18)	13.2 (1.47)	143.7	
12		8.20 (1.19)	15.97 (1.78)	143.5	



TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 9/1/78  
 TEST SAMPLE NITROCELLULOSE 1-0 5 ALCOHOL MIL-N 244A TIME 1435  
 SAMPLE WEIGHT 45 kg (99 lb) TEMP. 33.3°C (92°F)  
 INITIATION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 37%  
 BOOSTER WEIGHT 5.26 kg (11.6 lb) BAR. PRESS. 29.99  
 TEST NO 04 (35-8-06) WIND DIR. 340  
 CONTRACT NO NAS12-50 WIND VEL. 3 knots



FIELD EVALUATION Detonation occurred, no hole in witness plate

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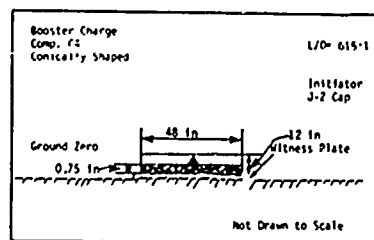


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TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 9/5/78  
 TEST SAMPLE NITROCELLULOSE 1-0 5 ALCOHOL MIL-N-244A TIME 1220  
 SAMPLE WEIGHT 45 kg (99 lb) TEMP. 32.2°C (90°F)  
 INITIATION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 36%  
 BOOSTER WEIGHT 5.26 kg (11.6 lb) BAR. PRESS. 29.96  
 TEST NO 04 (36-8-01) WIND DIR. 40°  
 CONTRACT NO NAS12-50 WIND VEL. 4 knots



FIELD EVALUATION Detonation occurred, no hole in witness plate

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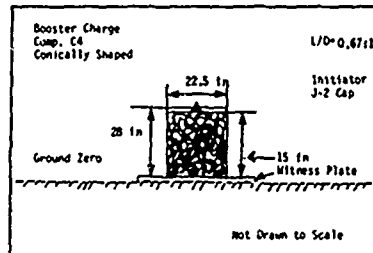
# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 45 kg (99 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	4.46 (14.63)	951.6 (138.01)	212.1 (23.63)	4.7	
2		1165.4 (169.03)	( )	4.5	
3	6.02 (19.75)	381.6 (55.34)	102.1 (11.38)	6.5	
4		501.5 (72.73)	112.6 (12.55)	6.0	
5	8 (26.24)	160.9 (23.34)	76.3 (8.5)	10.1	
6		222.4 (32.26)	75.7 (8.43)	9.3	
7	13.38 (43.89)	55.6 (8.07)	51.9 (5.79)	22.4	
8		63.9 (9.27)	57.3 (6.38)	21.7	
9	26.76 (87.79)	24.9 (3.61)	40.7 (4.54)	56.7	
10		20.1 (2.92)	36.5 (4.07)	56.4	
11	59.46 (195.08)	9.17 (1.33)	20.37 (2.27)	145.9	
12		8.2 (1.19)	18.76 (2.09)	145.7	

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST 45 kg (99 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in 1/3 (psi msec/in 1/3)	Time of Arrival (msec)	Remarks
1	4.46 (14.63)	908.9 (131.87)	115.8 (15.13)	4.6	
2		930.5 (134.96)	148.9 (16.59)	4.7	
3	6.02 (19.75)	379 (54.97)	106.2 (11.92)	6.6	
4		340.5 (50.26)	83.5 (9.3)	6.7	
5	8 (26.24)	170.7 (24.74)	39 (4.35)	10.2	
6		185 (26.87)	66.5 (7.41)	10.4	
7	13.38 (43.89)	54.4 (7.89)	60.8 (6.77)	21.7	
8		60.3 (8.74)	52.2 (5.82)	22.7	
9	26.76 (87.79)	22.3 (3.23)	39.9 (4.45)	57	
10		18.3 (2.65)	37.2 (4.14)	57.15	
11	59.46 (195.08)	7.52 (1.07)	12.03 (1.34)	145.8	
12		7.86 (1.14)	17.41 (1.94)	146.6	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/23/78  
 TEST SAMPLE NITROCELLULOSE 14-SS ALCONOL MIL-R-244A TIME 1043  
 SAMPLE WEIGHT 63.5kg (140 lb) TEMP. 31.1°C (88°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 45%  
 BOOSTER WEIGHT 6.35kg (14 lb) Composition C4 BAR. PRESS. 30.08  
 TEST NO. E1 (34-B-01) WIND DIR. 260°  
 CONTRACT NO. NAS13-50 WIND VEL. 3 knots

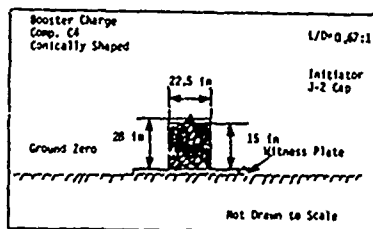


FIELD EVALUATION: Detonation; a clean hole in witness plate; still photographs taken of set-up and posttest. No motion picture taken.

# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 63.5 kg (140 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in. 1/3 (psi msec/in. 1/3)	Time of Arrival msec	Remarks
1	4.75	1028.9 (148.65)	118.4 (13.19)	4.5	
2	(15.58)	1205.8 (166.49)	164.2 (18.3)	4.5	
3		486.8 (70.6)	134.5 (14.99)	6.2	
4	6.32 (20.77)	538.8 (78.14)	138.2 (15.4)	6.25	
5		264.6 (38.77)	91.4 (10.18)	9.55	
6	8.55 (28.04)	245 (35.54)	95.6 (10.65)	9.6	
7		86 (12.47)	59.9 (6.68)	21.2	
8	14.24 (46.73)	86.9 (12.61)	55.7 (6.21)	21.35	
9		25.1 (3.64)	34.7 (3.87)	57	
10	28.49 (93.46)	21.2 (3.07)	31.7 (3.53)	57.2	
11		8.41 (1.22)	13.73 (1.53)	152.1	
12	63.32 (207.73)	7.24 (1.05)	14.81 (1.65)	153.8	

TEST TITLE TNT EQUIVALENCY NITROCELLULOSE DATE 8/24/78  
 TEST SAMPLE NITROCELLULOSE 14-SS ALCONOL MIL-R-244A TIME 1534  
 SAMPLE WEIGHT 63.5kg (140 lb) TEMP. 32.8°C (91°F)  
 IGNITION SOURCE J2 ENGINEERS' SPECIAL BLASTING CAP HUMIDITY 45%  
 BOOSTER WEIGHT 6.35kg (14 lb) Composition C4 BAR. PRESS. 30.04  
 TEST NO. E2 (34-B-04) WIND DIR. 145°  
 CONTRACT NO. NAS13-50 WIND VEL. 15 knots



FIELD EVALUATION: Detonation occurred; a clean hole in the witness plate.

Still & motion pictures taken of set-up and posttest. No motion pictures taken.

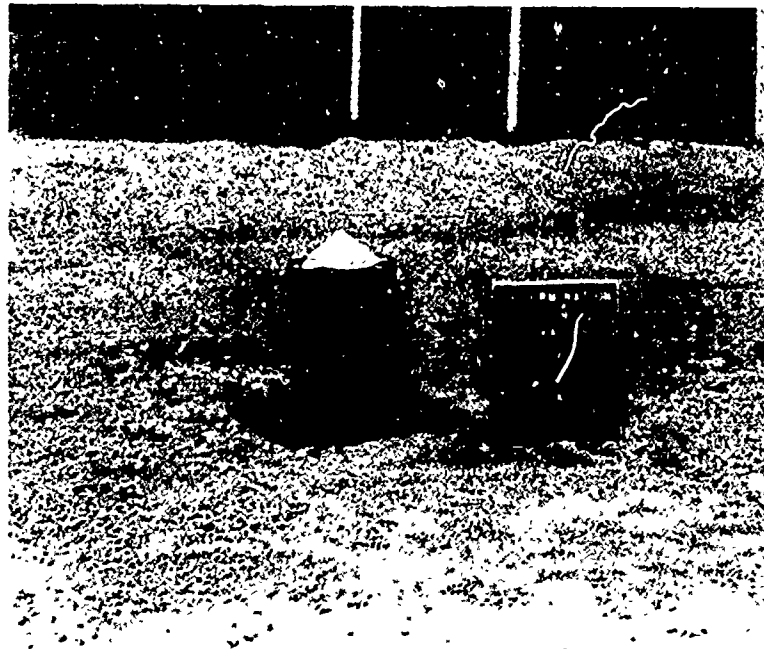
# EXPERIMENTAL RESULTS

TNT EQUIVALENCY TEST: 63.5 kg (140 lb)					
Channel Number	Distance Meters (ft)	Peak Pressure kPa (psi)	Scaled Impulse kPa msec/in. 1/3 (psi msec/in. 1/3)	Time of Arrival msec	Remarks
1	4.75	1257.9 (180.94)	207.1 (22.52)		No Timing Marks
2	(15.58)	1337.1 (193.93)	179.1 (19.96)		No Timing Marks
3		428.2 (62.12)	106.7 (11.89)		No Timing Marks
4	6.32 (20.77)	423.3 (61.4)	66.1 (7.36)		No Timing Marks
5		240.4 (34.86)	97 (10.81)		No Timing Marks
6	8.55 (28.04)	276.4 (40.09)	92 (9.92)		No Timing Marks
7		( )	( )		Unable to Retrieve from Mag Tape
8	14.24 (46.73)	( )	( )		Unable to Retrieve from Mag Tape
9		30 (4.35)	34.17 (3.83)		No Timing Marks
10	28.49 (93.46)	( )	( )		Unable to Retrieve from Mag Tape
11		( )	( )		Unable to Retrieve from Mag Tape
12	63.32 (207.73)	( )	( )		Unable to Retrieve from Mag Tape

APPENDIX B

SELECTED PHOTOGRAPHS

APPENDIX B  
SELECTED PHOTOGRAPHS



Pretest Configuration 11.34-kg Charge



Posttest Crater 11.34-kg Charge

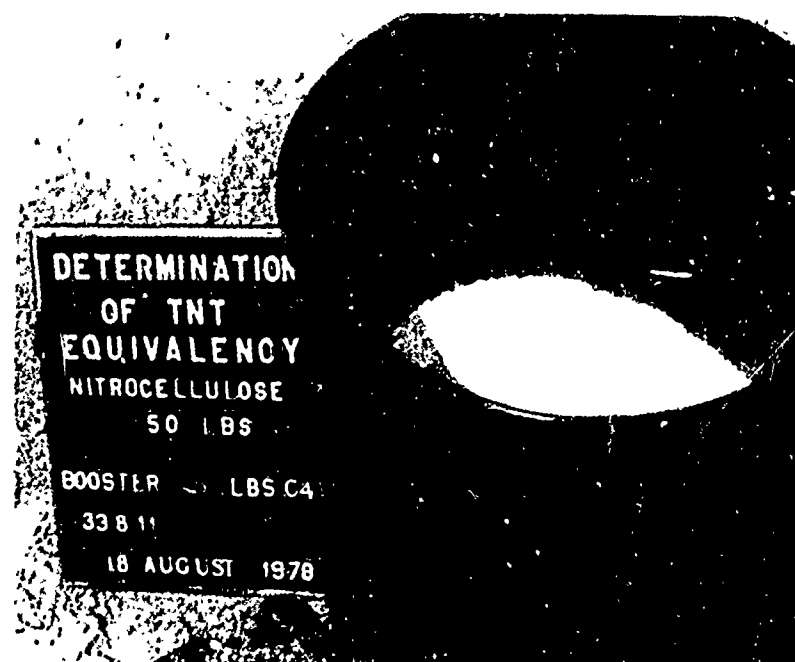
DETERMINATION  
OF TNT  
EQUIVALENCY  
NITROCELLULOSE  
42.25 LBS  
MUSTER 4.3 LBS C4  
24 11 07  
28 AUGUST 1976



Pretest Configuration 19.5-kg Charge

DETERMINATION  
OF TNT  
EQUIVALENCY  
NITROCELLULOSE  
42.25 LBS  
MUSTER 4.3 LBS C4  
24 11 07  
28 AUGUST 1976

Posttest Crater and Witness Plate 19.5-kg Charge



Pretest Configuration 22.68-kg Charge



Posttest Crater and Witness Plate 22.68-kg Charge



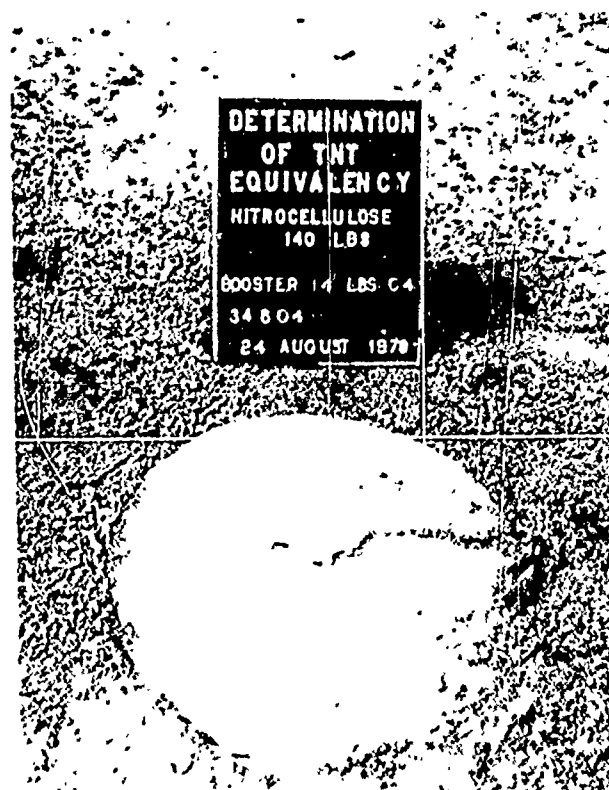
Pretest Configuration before Drying 45 kg Charge



Posttest Crater and Witness Plate 45 kg Charge



Pretest Configuration 63.5-kg Charge



Posttest Crater and Witness Plate 63.5-kg Charge



APPENDIX C

TNT EQUIVALENCY PROGRAM

## APPENDIX C

### TNT EQUIVALENCY PROGRAM

This program calculates the pressure and impulse TNT equivalency by an iterative process which factors out the contributions from C4 booster charges\*. For each set of input data, the parameters are calculated according to the following procedure:

1. Assume zero contribution from the booster charge. Then  $W1 = W2 = W$ , where  $W1$  and  $W2$  are the pressure- and impulse-related sample weights, respectively, and  $W$  is the sample charge weight.

2. Calculate approximate sample scaled distances from

$$Z1 = R / (W1)^{1/3} \quad (\text{pressure})$$

$$Z2 = R / (W2)^{1/3} \quad (\text{impulse})$$

3. Calculate an approximate TNT (equivalent) scaled distance,  $Z5$ , from the estimated sample TNT impulse equivalency,  $E5$ :

$$Z5 = Z2 / (.01 E5)^{1/3}$$

4. Calculate the TNT pressure and impulse scaled distances,  $Z3$  and  $Z4$  respectively, from curve-fits of reference data, see figure A1. Use separate straight line (log-log) segments depending on the value of  $Z5$ :

(a) If  $Z5 \leq 9$ ,

$$Z3 = 27.133 P^{-0.4513}$$

$$Z4 = 47.247 I^{-(1/1.8215)}$$

(b) If  $9 < Z5 \leq 18$ ,

$$Z3 = 36.016 P^{-0.5672}$$

$$Z4 = 55.874 I^{-(1/1.5672)}$$

(c) If  $Z5 > 18$ ,

$$Z3 = 45.555 P^{-0.7557}$$

$$Z4 = 67.37 I^{-(1/1.9626)}$$

\* Swatosh, J. J., and J. Cook, "TNT Equivalency of M1 Propellant (Bulk), Technical Report 4885, Ploatinny Arsenal, December 1975.

5. Calculate the approximate TNT pressure and impulse equivalencies, E1 and E2, from:

$$E1 = (Z1)^3 / (Z3)^3$$

$$E2 = (Z2)^3 / (Z4)^3$$

6. Using the equivalencies obtained in step 5, recalculate the pressure- and impulse-related sample weights, and the estimated TNT impulse equivalency:

$$W1 = W + (W3)(1.25/E1)$$

$$W2 = W + (W3)(1.25/E2)$$

$$E5 = (100)(E2)$$

where W3 is the booster charge weight.

7. Using the values obtained in step 6, work through from step 2 again to obtain new, improved values for E1, E2, W1, W2, and E5. Each iteration improves both the curve-fits in step 4 and the minimization of booster contributions in step 6. Continue the iteration until changes in E1 and E2 are insignificant.

8. Begin calculation for a new set of data at step 1.

The entire program with 10 sets of input data requires less than 4 Kbytes of memory. Therefore it can be used in small, portable microcomputer systems and desktop programmable calculators. The mean accuracy of the calculations over the range of scaled distances from 2.5 to 60 is about 1%. The maximum errors occur at scaled distances of 9 and 18, i.e., the inflection points of the straight-line TNT data curve fits, and amount to less than 5% of the calculated equivalencies.

# TNT EQUIVALENCY PROGRAM

```

100 REM      INPUT DATA REQUIRED IS:
110 REM      (1) MATERIAL, CONFIGURATION, APPX. EQUIVALENCY
120 REM      (2) SAMPLE WT, BOOSTER WT, DISTANCE, PRESSURE,
130 REM      IMPULSE UP TO 10 CALCULATIONS CAN BE MADE IN
140 REM      ONE PASS.
150 INIT
160 DIM W(10), W3(10), R(10), Z(10), P(10), I1(10), I2(10)
170 DIM E1(10), E2(10)
180 PRINT "MATERIAL?"
190 INPUT M$
200 PRINT "CONFIGURATION?"
210 INPUT C$
220 PRINT "APPROXIMATE % EQUIVALENCY?"
230 INPUT E5
240 I=0
250 I=I+1
260 N1=I
270 PRINT "INPUT W(LB), BOOSTER(LB), R(FT), P(PSI), I(PSI*MSEC)"
280 INPUT W(I), W3(I), R(I), P(I), I1(I)
290 Z(I)=R(I)/W(I)+0.333
300 I1(I)=I1(I)/W(I)+0.333
310 PRINT "ANY MORE DATA?"
320 INPUT L$
330 IFL$= "Y" THEN 250
340 FOR I=1 TO N1
350 W1=W(I)
360 W2=W(I)
370 Z1=R(I)/W1+0.333
380 Z2=R(I)/W2+0.333
390 Z5=Z2/(0.01*E5)+0.333
400 IF Z5 > 18 THEN 520
410 IF Z5 > 9 THEN 470
420 A1=27.133
430 B1=0.4513
440 A2=47.247
450 B2=0.8215
460 GO TO 560
470 A1=36.016
480 B1=0.5672
490 A2=55.874
500 B2=0.8979
510 GO TO 560

```

```

520 A1=45.555
530 B1=0.7557
540 A2=67.37
550 B2=0.9626
560 B=1/(1+B2)
570 Z3=A1/P(I)+B1
580 Z4=(A2*Z2/I1(I))+B
590 E1(I)=Z1+3/Z3+3
600 E2(I)=Z2+3/Z4+3
610 W1=W(I)+W3(I)*1.25/E1(I)
620 W2=W(I)+W3(I)*1.25/E2(I)
630 E5=100*E2(I)
640 PRINT USING 650:"E(P)=", E1(I), "E(I)=", E2(I)
650 IMAGE 8X, 5A, 2X, 4D, 2D, 10X, 5A, 2X, 4D, 2D
660 PRINT "ITERATE AGAIN? ? ?"
670 INPUT T$
680 IF T$=>"Y" THEN 370
690 E1(I)=100*E1(I)
700 E2(I)=100*E2(I)
710 NEXT I
720 PAGE
730 PRINT USING 740:"TNT EQUIVALENCY OF", M$
740 IMAGE 18X, 19A, 3X, 20A/
750 PRINT USING 760:"CONFIGURATION:", C$
760 IMAGE 14X, 15A, 3X, 30A//
770 PRINT USING 780:"W", "R", "Z", "P", "I", "E(P)", "E(I) "
780 IMAGE 4X, 1A, 9X, 1A, 9X, 1A, 9X, 1A, 9X, 1A, 8X, 4A, 6X, 4A
790 PRINT USING 800:"LB", "FT", "SCALED", "PSF", "SCALED", "(%)", "(%) "
800 IMAGE 4X, 2A, 8X, 2A, 6X, 6A, 5X, 3A, 6X, 6A, 5X, 3A, 7X, 3A/
810 FOR I=1 TO N1
820 PRINT USING 830:W(I), R(I), Z(I), P(I), I1(I), E1(I), E2(I)
830 IMAGE 1X, 3D, 3D, 2X, 4D, 3D, 2X, 4D, 3D, 2X, 4D, 3D, 2X, 4D, 3D, 3X, 4D, 3X, 4D/
840 NEXT I
850 END

```

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